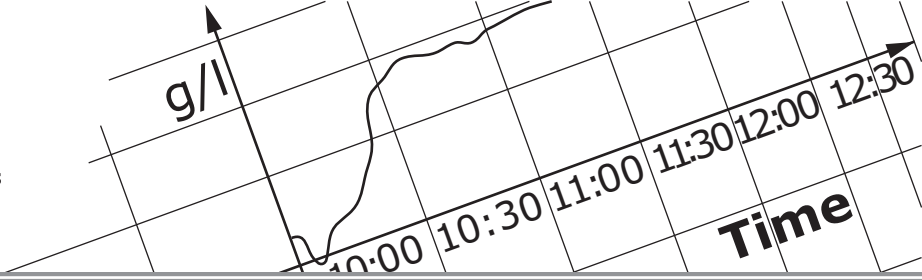
BERTHOLD TECHNOLOGIES

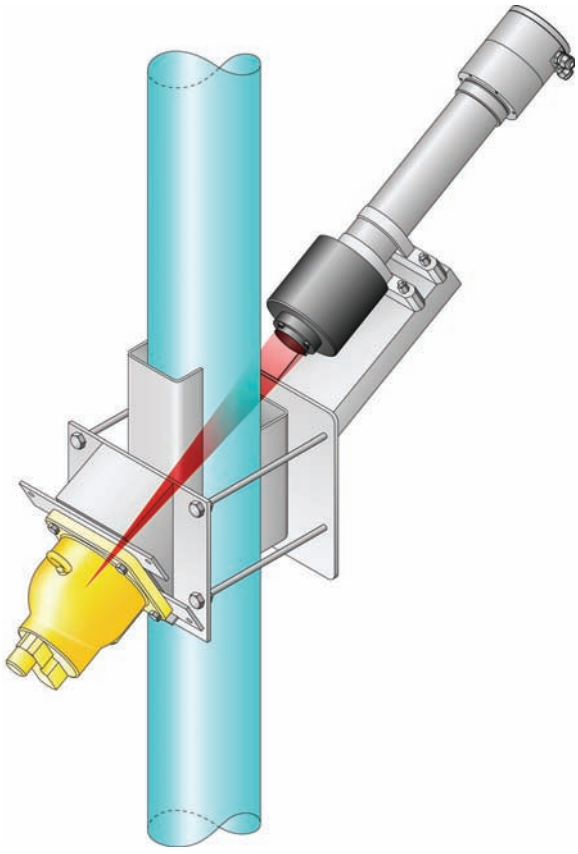


detect and identify

Process Control

sensseries LB 480

Density measurement



User's Manual

Id.-Nr. 54733-30BA2D

Rev.-Nr.: 00 15.2.13
Embedded Soft. Rev. 00
Device Description 00

Volume 1: Safety Manual 1

Volume 2: Installing SENSseries 2

Volume 3: Operation with HART® Communicator 3

General Information

Dear customers
sehr geehrter Kunde

Thank you for purchasing the measuring system SENSseries LB 480 by BERTHOLD TECHNOLOGIES.

The scope of supply also includes this User's Manual. Keep this User's Manual on hand for reference at any time.

Please observe the warnings and safety instructions given in this User's Manual to rule out personal injury and property damage. They are identified by the following symbols: DANGER, WARNING, CAUTION or IMPORTANT. In *Volume 1*, *"Meaning of Other Symbols Used in this Documentation"*, you find an overview of the hazards to be observed and instructions on how to deal with these hazards.

Please read this User's Manual prior to installation to get familiar with the product.

If you do encounter problems despite careful study of the User's Manual, please do not hesitate to contact us.

Your BERTHOLD team

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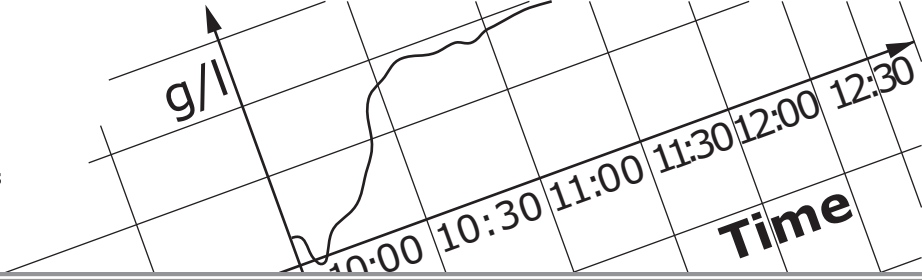

Volume 1 Safety Manual

1

About this User's Manual

1.1 Typographical Conventions

The symbols and typefaces used in this User's Manual have the following meaning:

▶	prompts you to carry out an action.
1, 2, 3, ...	identifies items in a graphic.
•	identifies enumerations.
italic typeface	highlights important information.
bold typeface	indicates commands or menu items.
bold italic	identifies user entries.

The term BERTHOLD TECHNOLOGIES is used in this User's Manual for the company BERTHOLD TECHNOLOGIES GmbH & Co. KG.

Please observe the warnings and safety instructions given in this User's Manual to rule out personal injury and property damage. They are identified by the following symbols: DANGER, WARNING, CAUTION or IMPORTANT.

⚠ DANGER

Indicates a direct threat of danger. The consequences will be death or Subject to change in the course of further technical development.02.201354733-30BA2Dmost severe personal injuries.

⚠ WARNING

Indicates a possibly dangerous situation. If the situation is not avoided, death or serious bodily injury could result.

⚠ CAUTION

Indicates a possibly dangerous situation. If the situation is not avoided, minor or moderate bodily injury could occur.

NOTICE

Indicates a situation which could result in material damage if the instructions are not observed.

IMPORTANT

Paragraphs marked with this symbol provide important information on the product and on handling the product.

Tip

Includes application tips and other helpful information.

1.2 Meaning of Other Symbols Used in this Documentation

Warning: Do not step or stand under a suspended load.

Warning: Radiation

Warning: Ex-protection

Warning: Risk of crushing

Requirement: Switch off power

Requirement: Wear a hardhat

Requirement: Wear safety shoes

1.3 Meaning of Warning Signs on Detectors and Source Shieldings

Warning: Radiation
This warning is located on the source shielding.

Warning: Please read the User's Manual prior to installation
This warning is located on or in the terminal compartment of the detector.

1.4 Terms Used in this User's Manual

CrystalSENS — Standard point detector version in the SENSseries LB 480.

UniSENS — Standard rod detector version in the SENSseries LB 480.

SuperSENS — Highly sensitive detector with large volume plastic scintillator 150 x 150 mm for large pipe or tank diameter.

TowerSENS — Rod detector with an especially large potential measuring length. In contrast to multi-detector configurations, only one detector is required here.

NaI detector — NaI = sodium iodide crystal = scintillator

Scintillation detectors are very sensitive probes for gamma radiation.

Isotope — Substance of the radiation source, e.g. Cobalt 60 (Co-60) or Cesium 137 (Cs-137).

Count rate — Value for the number of pulses standardized to one second.

Background — The count rate caused by the natural environmental radiation.

Cps — Unit for the count rate: *C*ounts *p*er *s*econd.

Factory setting — In the factory setting, all parameters are preset with default values. In most cases, this makes calibration of the detector a lot easier. Nevertheless, a calibration must *always* be carried out.

mSv — Milli-Sievert: The unit indicates the dose rate (dose equivalent).

mrem — Milli-rem (roentgen equivalent in man): traditional unit for the dose rate (100 mrem = 1 mSv).

MBq — Mega Becquerel: The unit indicates the activity of a source. Each Bq corresponds to one disintegration per second, i.e. 1 MBq equals one million disintegrations.

mCi — Milli-Curie: Traditional unit for the activity of a source (1 mCi = 37 MBq).

ATEX — Atmosphère explosive: is used as a generic term for the ATEX Product Directive 94/9/EC and the ATEX Workplace Directive 1999/92/EC. The directives contain provisions for equipment and components for use in explosion hazardous areas.

FM — Factory Mutual: an American industrial property insurance company that, among other things, issues certifications in the field of explosion protection.

CSA

Canadian Standard Association: sets norms and standards that are important for Canada (and America), among other things, the Directive for Explosion Protection and Low Voltage.

PMT

Photomultiplier or only multiplier: converts the flashes of light generated by the radiation in the detector into electrical signals.

HV

HV = High voltage

The multiplier is operated at high voltage, so that flashes of light can be converted into electrical pulses.

The high-voltage control allows for measurements that are stable to temperature and aging. Each multiplier has a slightly different sensitivity, and must therefore be operated at a different high voltage.

The multiplier is operated at high voltage, so that flashes of light can be converted into electrical pulses.

The high-voltage control allows for measurements that are stable to temperature and aging. Each multiplier has a slightly different sensitivity, and must therefore be operated at a different high voltage.

Zero count rate

Count rate where the measurement indicates the measured value 0. For example, if g/cm^3 has been selected as the unit, 0 g/cm^3 will be displayed at this count rate. The count rate is calculated from the calibration points after **Calibrate** has been enabled. Together with the coefficients A1, A2 and A3, it determines the characteristic curve of the measurement.

1.5 General Information

The most important safety measures are summarized in this volume. It supplements the appropriate provisions which the staff in charge is *obliged* to follow.

Please pay attention to:

– the national safety and accident prevention regulations

– the national assembly and installation directions (for example, EN 60079)

– the generally accepted engineering rules

– the information on transport, assembly, operation, service, maintenance in this User's Manual

– the safety instructions and information in this User's Manual and the enclosed technical drawings and wiring diagrams

– the parameters, limit values and the information on operating and ambient conditions on the type labels and in the data sheets

– the labels on the device

2

Proper Use

The measuring system SENSseries LB 480 is a detector which, depending on its design, can be used for different measurement tasks:

– Level measurement

– Monitoring limit values

– Density measurement

The measurement system is designed for the continuous monitoring and detection of levels and limit levels of liquids and bulk solids in bins, or to determine the density of liquids in tanks and pipes. The proper use is defined in the project planning stage by BERTHOLD TECHNOLOGIES, the system delivered may be used only for this purpose.

If the detector is used in a way which is not provided for during the project planning stage and which is not described in the User's Manual, then the detector's protection is compromised and the guarantee claim becomes invalid.

BERTHOLD TECHNOLOGIES only accepts liability for / guarantees the correspondence of the systems of the SENSseries LB 480 to its published specifications. The detectors of the SENSseries may only be installed in an undamaged, dry and clean condition.

Conformity to standards

The standards and guidelines the SENSseries complies with are itemized in the CE conformity declaration.

Limits of use

The detectors of the SENSseries LB 480 are *not* qualified as "safety-relevant measurements".

Warning about misuse

The following use is inappropriate and has to be prevented:

- Use under other conditions and prerequisites than those specified by the manufacturer in his technical documents, data sheets, operating and assembly instructions and other specifications.
- The repair of detectors that are used in explosion hazardous areas by persons who were not authorized by BERTHOLD TECHNOLOGIES.
- Using the device in a damaged or corroded condition.
- Operation with open or inadequately closed cover.
- Operation with inadequately tightened adapters and cable glands.
- Operation without the safety precautions provided by the manufacturer.
- Manipulating or bypassing existing safety installations.

Maintenance

The measuring system of the SENSseries LB 480 may only be installed, serviced and repaired by by trained persons (see *chapter 3.2*, *page 1-20*).

Repair

Spare parts for detectors used in the Ex-area may be assembled only by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES. If this is not possible, you must replace the entire detector or return it to the manufacturer for repair.

Parameter settings

Never change the parameter settings without a full knowledge of this User's Manual, as well as a full knowledge of the behavior of the connected controller and the possible influence on the operating process to be controlled!

Sources and shieldings

This measuring system uses radioactive sources. The radiation protection instructions in this User's Manual and the relevant statutory provisions are to be observed strictly, see also *chapter 7, "Visual Inspection"*, *page 1-53*.

3

Qualification of the Personnel

At different parts in this User's Manual, reference is made to personnel with certain qualifications who can be entrusted with different tasks during the installation, operation and maintenance.

These three groups of people are:

1. Persons with a general knowledge, see *chapter 3.1*.
2. Experts, see *chapter 3.2*.
3. Authorized persons, see *chapter 3.3*.

The following chapters explain the meaning of these terms and the prerequisites for the particular group of people.

IMPORTANT
All work on and with the measurement systems SENSseries LB 480 must be performed by persons having at least a general knowledge; they must always be guided by an expert or an authorized person.

3.1 Persons with a General Knowledge

Persons with a general knowledge are e.g. technicians or welders who can undertake different tasks during the transportation, assembly and installation of the measuring systems SENSseries LB 480 under the guidance of an authorized person. This can also refer to construction site personnel. The persons in question must have experience in the transportation and assembly of heavy component parts.

Persons working with Ex devices must in addition have knowledge on how to work with these devices, for example, that the devices must not be subject to mechanical damage (blow, etc.).

IMPORTANT
Persons with a general knowledge must always be guided by a trained expert at the very least.
When dealing with radioactive substances, a Radiation Safety Officer must also be consulted.

3.2 Experts

Experts are persons who have sufficient knowledge in the required area due to their specialist training and who are familiar with the relevant national health and safety regulations, accident prevention regulations, guidelines and recognized technical rules. Expert personnel must be capable of safely assessing the results of their work and they must be familiar with the content of this User's Manual.

3.3 Authorized Persons

Authorized persons are those who are either designated for the corresponding task due to legal regulations or those who haven been authorized by BERTHOLD TECHNOLOGIES for particular tasks. When dealing with radioactive materials, a Radiation Safety Officer must also be consulted.

4

Transport and Assembly

The weight of the source shielding may be up to several 100kg, depending on the version. Please keep in mind:

- The bearing capacity of the container walls or the brackets must be suitable for installation of the source with the shielding and of the detector. Otherwise, system parts may fall off and cause severe injuries or bodily harm with fatal consequences.
- Make sure that the mechanical stability of the fixing devices matches the weight of the shielding.

Please keep in mind:

– Never step under hovering loads while unloading heavy system parts!

– Only use tested lifting equipment matching the transport weights.

– Maintain adequate safety margin.

– Wear hard hat and safety shoes.

– Always ensure good stability for all types of use.

– Make use of the prepared mounting options.

– Work during assembly and installation of heavy and unwieldy subassemblies should be carried out by at least two people.

– System components must be mounted vibration-free.

5

Explosion Protection

SENSseries

LB 480 - .. 1A
LB 480 - .. 2A

Safety Manual
ATEX / IECEx

This safety manual provides operating instructions in accordance with the Directive 94/9/EC and the explosion protection standards mentioned in the Declaration of Conformity.

Please observe the instructions given in this safety manual to avoid personal injury and property damage and to ensure safe operation.

ID no. 54733BA26

Rev. no.: 00 15.2.13

(bg) Инструкции за безопасност за употреба в потенциално експлозивни райони. Това ръководство за безопасност е и на разположение на официалните езици на Европейския съюз.

(cs) Bezpečnostní pokyny pro použití v oblastech, kde hrozí nebezpečí výbuchu. Tato příručka s bezpečnostními pokyny je k dispozici i v úředních jazycích Evrospké unie.

(da) Skkerhedsvejledning til brug i eksplosionsfarlige omgivelser. Denne sikkerhedsmanual findes på alle officielle sprog i det Europæiske fælleskab.

(de) Sicherheitshinweise für den Einsatz in explosionsgefährdeten Bereichen. Dieses Sicherheitshandbuch ist auch in den Amtssprachen der europäischen Gemeinschaft erhältlich.

(el) Υποδείξεις ασφάλειας για χρήση σε περιοχές με κίνδυνο έκρηξης. Αυτό το εγχειρίδιο ασφάλειας διατίθεται επίσης στις επίσημες γλώσσες της Ευρωπαϊκής Ένωσης.

(en) Safety instructions for use in potentially explosive areas. This safety manual is available also in the official languages of the European Community.

(et) Ohutusjuhised kasutamiseks plahvatusohtlikes piirkondades. Käesolev ohutuskäsiraamat on saadaval ka Euroopa Ühenduse ametlikes keeltes.

(fi) Räjähdysvaarallisilla alueilla käyttöä koskevat turvallisuusohjeet. Tämä turvaohjekirja on saatavilla myös Euroopan yhteisön virallisilla kielillä.

(fr) Consignes de sécurité relatives à une utilisation en zones explosives. Le présent manuel de sécurité est également disponible dans les langues officielles de la communauté européenne.

(ga) Treoracha sábháilteachta le haghaidh úsáide i limistéir inphléasctha Tá an lámhleabhar sábháilteachta seo ar fáil i dteangacha oifigiúla an Aontais Eorpaigh, chomh maith.

(hu) Biztonsági utasítások robbanásveszélyes területeken történő alkalmazáshoz. Ez a biztonsági kézikönyv az Európai Közösség hivatalos nyelvein is rendelkezésre áll.

(it) Istruzioni per l'impiego in ambienti a rischio di deflagrazione. Il presente manuale contiene le disposizioni di sicurezza ed è disponibile in tutte le lingue ufficiali della comunità europea.

(lt) Saugumo nurodymai naudojimui potencialiai sprogiose zonose. Šį saugumo vadovą taip pat galima gauti Europos Bendrijos oficialiomis kalbomis.

(lv) Drošības noteikumi piemērošanai jomās, kas saistītas ar sprādzienbīstamību. Šī drošības noteikumu rokasgrāmata ir pieejama arī citās Eiropas Kopienas oficiālajās valodās.

(mt) Istruzzjonijiet dwar is-sigurtà li għandhom jintużaw f'żoni potenzjalment splussivi. Dan il-manwal tas-sigurtà huwa disponibbli wkoll fl-ilsna uffiċjali kollha tal-Komunità Ewropea.

(nl) Veiligheidsinstructies voor de inzet in gebieden met gevaar voor explosies Dit veiligheidshandboek is ook in officiële talen in de Europese Gemeenschap verkrijgbaar

(pl) Przepisy bezpieczeństwa dotyczące użytkowania na obszarach zagrożonych wybuchem. Niniejsza instrukcja bezpieczeństwa dostępna jest również w językach urzędowych Unii Europejskiej.

(pt) Indicações de Segurança para a utilização em áreas potencialmente explosivas. Este Guia de Segurança também está disponível nas línguas oficiais da Comunidade Europeia.

(ro) Instructiuni de siguranţă pentru utilizarea în zone periculoase. Acest manual de siguranţă este de asemenea disponibil în limbile oficiale ale Comunităţii Europene.

(sk) Bezpečnostné pokyny pri použití vo výbušnom prostredí. Táto bezpečnostná príručka je k dispozícii aj v úradných jazykoch Európskej únie.

(sl) Varnostna navodila za uporabo v eksplozijsko ogroženih območjih. Ta varnostni priročnik je na voljo tudi v uradnih jezikih Evropske unije.

(sp) Instrucciones de seguridad para el uso en áreas explosibles. El presente manual de seguridad está disponible también en las lenguas oficiales de la Comunidad Europea.

(sv) Säkerhetshänvisningar till användning i områden som är utsatt för exlposionsfara. Denna handbok finns även tillgänglig i alla officiella språk av den europäiska gemenskapen.

5.1 Declaration of Conformity

BERTHOLD TECHNOLOGIES GmbH & Co. KG
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Fax +49 7081 177-100
info@Berthold.com
www.Berthold.com

EC-Declaration of Conformity

We, hereby declare under our sole responsibility that the design of the following products / systems / units brought into circulation by us comply with the relevant EC regulations.

This declaration loses its validity should modifications or unsuitable and improper use take place without our authorisation.

Description: ***measurement system for level and density sensSeries***

Typ: ***LB 480***

	directive	changes	applied standards	
EMC	2004/108/EC		EN 61326-1	2006
			EN 61326-3-1	2008
			EN 61000-3-2	2006
			EN 61000-3-3 + A1 + A2	1995
			EN 61000-4-2 + A1 + A2	1995
			EN 61000-4-3	2006
			EN 61000-4-4	2004
			EN 61000-4-5	2006
			EN 61000-4-6	2007
			EN 61000-4-8 + A1	1993
			EN 61000-4-11	2004
			Namur NE21	2007
RoHS	2011/65/EG			
Explosion Proof	94/9/EC PTB 11 ATEX 1032 X		EN 60079-0 EN 60079-1 EN 60079-7 EN 60079-31	2009 2007 2007 2009
notified body: 0102 PTB Braunschweig, Germany			EN 61010-1	2001

This declaration is issued by the manufacturer

BERTHOLD TECHNOLOGIES GmbH & Co. KG
Calmbacher Str. 22, D-75323 Bad Wildbad, Germany

released by

Dr. Wilfried Reuter
Technical Director
Bad Wildbad, 10th of May, 2012

Registergericht / Court of Registration: Stuttgart HRA 330991
Persönlich haftende Gesellschafterin / Fully liable Associates: BERTHOLD TECHNOLOGIES Verwaltungs-GmbH
Registergericht / Court of Registration: Stuttgart HRB 331520
Geschäftsführung / Management: Horst Knauff, Dr. Wilfried Reuter
USt.-Id-Nr. / VAT Reg. No.: DE813050511
Deutsche Steuernummer / German Tax No.: 49038/08038
WEEE-Reg. No.: DE99468690

Sparkasse PF-CW	75323 Bad Wildbad	Konto/Account No. 8 045 003 (BLZ 666 500 85)	SWIFT-BIC PZHSDE66	IBAN: DE37 6665 0085 0008 0450 03
Volksbank	75119 Pforzheim	Konto/Account No. 957 004 (BLZ 666 900 00)	SWIFT-BIC VBPFDE66	IBAN: DE85 6669 0000 0000 9570 04
Commerzbank	75105 Pforzheim	Konto/Account No. 6 511 120 (BLZ 666 800 13)	SWIFT-BIC DRES DEFF 666	IBAN: DE05 6668 0013 0651 1120 00

5.2 Improper Use

Warning about misuse

The following use is inappropriate and has to be prevented:

- Use under other conditions and prerequisites than those specified by the manufacturer in his technical documents, data sheets, operating and assembly instructions and other specifications.
- Repair of detectors that are used in explosion hazardous areas by persons who were not authorized by BERTHOLD TECHNOLOGIES.
- Using the device in a damaged or corroded condition.
- Operation with open or inadequately closed cover.
- Operation with
  - inadequately sealed glands,
  - inadequately tightened or damaged screwed fittings, i.e. cable glands, adapters and sealing plugs.
- Operation without the safety precautions provided by the manufacturer.
- Manipulating or bypassing existing safety installations.

5.3 Safety Instructions

5.3.1 Safety Instructions for Installation and Operating Personnel

Assembly, installation, commissioning, operation and maintenance must only be carried out by authorized and trained personnel.

Before assembly/commissioning:

- Read the safety manual
- Read the operating manual
- Provide adequate training for installation and operating personnel
- Ensure that the contents of the safety manual and the operating manual is fully understood by the relevant personnel.

If you are unclear:

- Contact the manufacturer.

Repair

Spare parts may solely be assembled by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES. If this is not possible, you must replace the entire detector or return it to the manufacturer for repair.

Ex-protection and temperature limits

Test certificates:	PTB 11 ATEX 1032 X IECEx PTB 12.0038X
Protection type:	IP66 / IP68 according to IEC 60529 IP69K according to ISO 20653
Air pressure:	80 kPa (0.8 bar) to 110 kPa (1.1 bar) Oxygen content of the air, typically: 21 % (Vi/V)

Zone	Identification			Max. surface temperature	Ambient temperature
	Directive 94/9/EC (ATEX)		Type of protection		
1 + 2	CE 0102 Ex	II 2 G	Ex db eb IIC T1-T5	T1 - T5	-40 °C ≤ Ta ≤ 80 °C
			Ex db eb IIC T6	T6	-40 °C ≤ Ta ≤ 65 °C
21 + 22	CE 0102 Ex	II 2 D	Ex tb IIIC T95 °C	95 °C	-40 °C ≤ Ta ≤ 80 °C
			Ex tb IIIC T80 °C	80 °C	-40 °C ≤ Ta ≤ 65 °C

Please note that the detector can be damaged at an ambient temperature of above 60 °C if water cooling fails.

The max. ambient temperature decreases when the detector is not mounted free-standing; the maximum surface temperature must under no circumstances be exceeded.

5.3.2 Installation

- Observe the installation and safety instructions of the operating manual.
- Install according to manufacturer's instructions and applicable standards and regulations.
- Do not operate device outside of the electrical, thermal and mechanical characteristics.
- To maintain the housing protection type, mount the housing cover and the screwed fittings (cable glands, adapters and sealing plugs) correctly.
- Unused entries must be sealed with metal sealing plugs.
- Please note also the operating and installation instructions of the screwed fittings in *Volume 2* , *chapter 6*.
- Attach the cap screws (M5x20) with spring washer (B5) with a torque of 4 Nm.
- Connect the electrical equipment to the local potential equalization.
- With shielded cables, the shielding has to be placed on the detector side. Observe an adequate insulation >500 V between the screen and the lines.
- Use a connection cable that is suitable for the ambient conditions.
- The connection cable (wire and insulation) must be suitable for a continuous operating temperature ≥ Ta +15 K.
- Connected cables must be installed strain-relieved.
- Do not disassemble the detector housing from the detector base (see *Fig. 5-3*).
- Use the detectors exclusively for stationary installation.
- Devices that were used in "non Ex-areas" must not be used in Ex-areas.
- The plan (checklist on *page 38*) for the control of the terminal compartment has to be completed before commissioning and every time the terminal compartment has been opened.

5.3.2.1 Increased Safety "e" in the terminal compartment

Screwed fittings

- Use only metallic screwed fittings M20 x 1.5 with protection type of at least IP65.
- For ambient temperatures between -20 °C and +40 °C, only those screwed fittings are permitted that are at least technically equivalent to the standard listed on the cover page of LB 480 EC type-examination certificate. Outside this temperature range one may only use screwed fittings which have been approved by BERTHOLD TECHNOLOGIES.
- Use only screwed fittings that are suitable for the type of cable (reinforced, non-reinforced, ...) and the cable cross-section.
- When using adapters for thread adjustment (e.g. thread reduction), only one adapter may be used in each cable gland.
- Replace the screwed fittings only by those of the same type.

Terminals

- Permissible wire cross-section:
  - with ferrules 0.5 - 1.5 mm² (AWG 21 - 16 flexible)
  - without ferrules 0.5 - 2.5 mm² (AWG 21 - 14 flexible or solid)
- Both stranded leads as well as solid wires are permitted.
- For connecting stranded leads, the following can be used: Ferrules or direct insertion of the strand into the terminal. The connection of fine-wire stranded lead class 6, according to IEC 60228, is only permitted with ferrules.
- Install the connecting cables in the terminal compartment so that
  - dirt and moisture is avoided in the terminal compartment;
  - the wires are not damaged when stripping;
  - the conductor insulation or the collar of the ferrule extends into the housing of the terminal body;
  - bare conductive parts of the lines (e.g. small wires of a strand) do not protrude from the terminal body;
  - the length of the ferrule or the stripped wire must be 10 mm, so that the wire is securely held in the spring-type terminal;
  - if ferrules are used, the conductor insulation extends into the collar of the ferrule;
  - clamped conductors and ferrules in the terminals must comply with a pull-out test according to DIN 46228 for 1 minute:
    30 N tensile force for 0.5 mm² cross-section and
    50 N tensile force for 2.5 mm² cross-section
    The crimped conductors in the ferrules must also pass this tensile test.

5.3.2.2 Commissioning

The HART® Communicator used must be capable of operating within the respective Ex zone.

5.3.2.3 Operation

- Do not open the terminal compartment while voltage is applied.
- If there is an explosive atmosphere: Waiting time before opening the electronics compartment after turning off the power supply:
  2 minutes.
- Continued operation is not allowed if:
  - the detector is damaged
  - threads on the housing are corroded
  - the detector housing is badly corroded
  - dummy plugs are badly corroded or damaged
  - cable glands are corroded or damaged
  - adapters are badly corroded or damaged
  - seals are damaged, show visible aging, or settlement.

5.4 Ex e – Concept

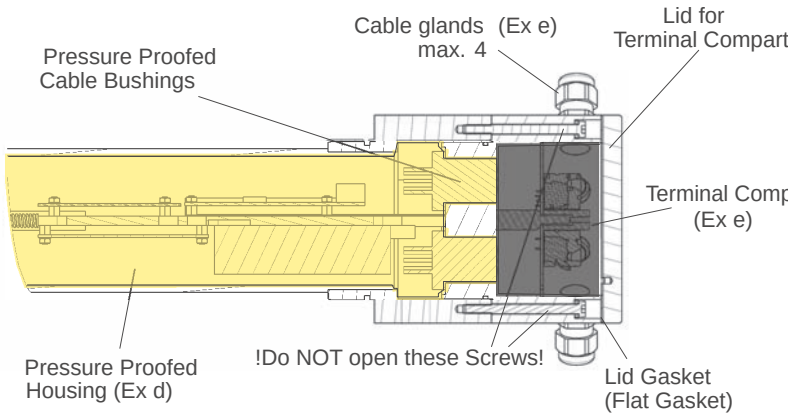


Fig. 5-1 Ex e – Concept

5.4.1 Installation plan for the type of protection increased safety "e"

Type

LB 480-..-1

LB 480-..-2

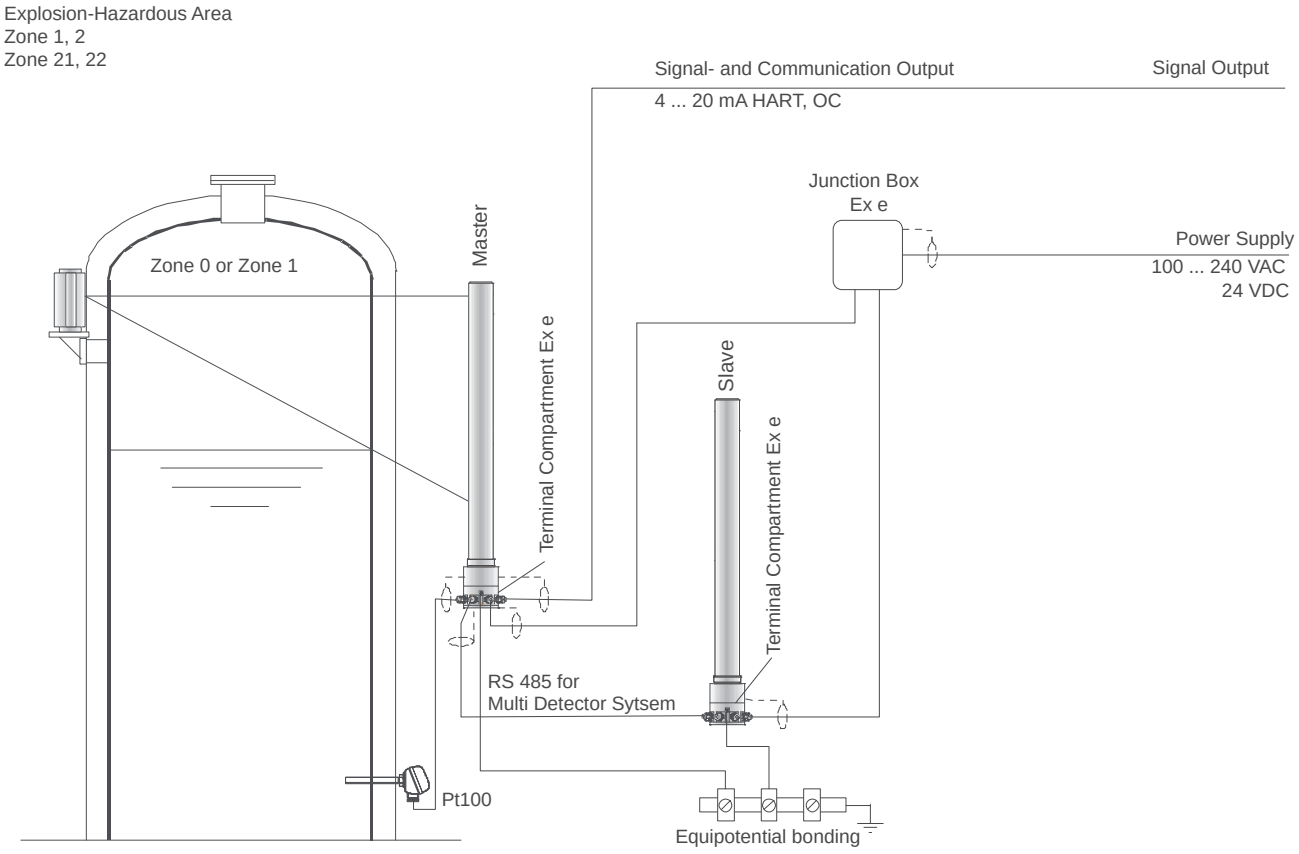
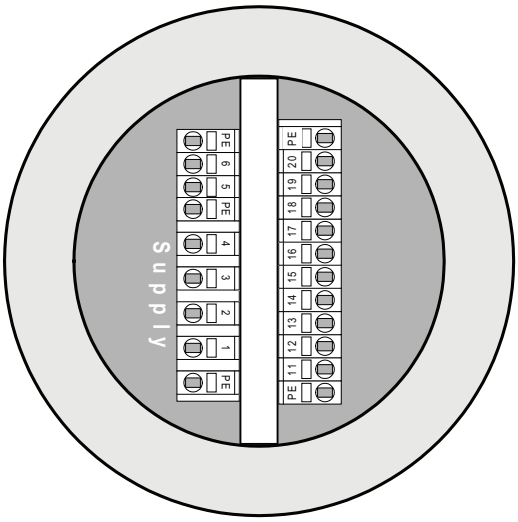
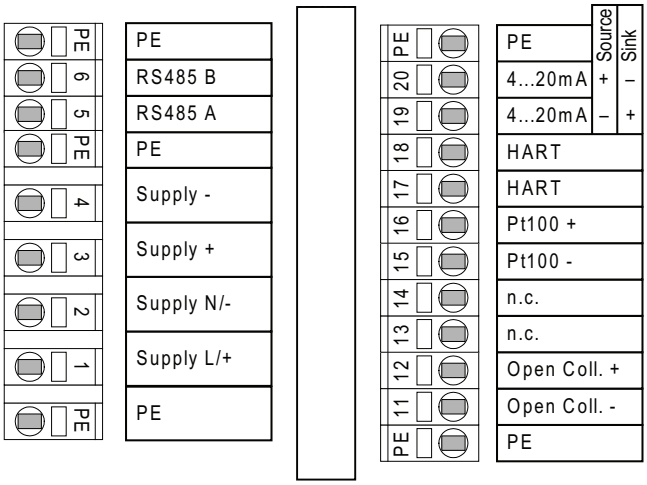


Fig. 5-2 Installation plan type of protection

5.4.2 Terminals

5.4.2.1 Master Terminal Compartment





Power supply

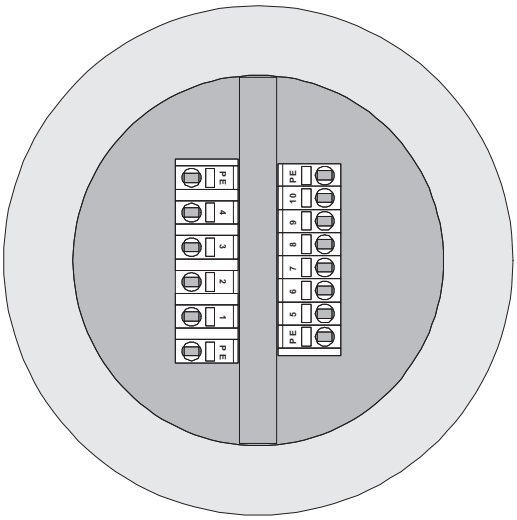
	Terminal	Labeling	
Type DC supply LB 480 - .. - .. - 11	1	Supply +	Ue = 24 VDC, max. 12 W
	2	Supply -	
	3	Supply +	To forward the supply to the next slave
	4	Supply -	
Type AC supply LB 480- .. - .. - 12	1	Supply L	Ue = 100 ... 240 VAC, 50/60 Hz, max. 12 VA
	2	Supply N	
	3	Supply +	Do not use to loop through the supply!
	4	Supply -	

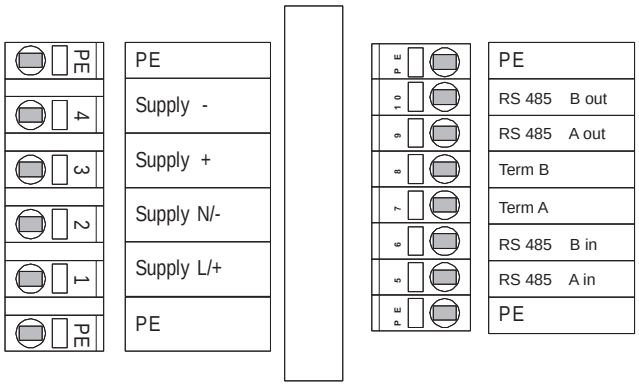
Do not connect any wires to the terminals "n.c.", as they are connected to the chassis ground.

Digital interface RS 485

Terminal	Labeling
5	RS 485 A
6	RS 485 B

5.4.2.2 Slave Terminal Compartment





Power supply

	Terminal	Labeling	
Type DC supply LB 480 - .. - .. - 01	1	Supply +	Ue = 24 VDC, max. 12 W
	2	Supply -	
	3	Supply +	To forward the supply to the next slave
	4	Supply -	
Type AC supply LB 480 - .. -.. - 02	1	Supply L	Ue = 100 ... 240 VAC, 50/60 Hz, max. 12 VA Um = 253 VAC
	2	Supply N	
	3	Supply +	Do not use to loop through the supply!
	4	Supply -	

Digital interface RS 485

Terminal	Labeling
5	RS 485 A In
6	RS 485 B In
9	RS 485 A Out
10	RS 485 B Out

5.4.2.3 Installation Instructions Cable Fittings and Dummy Plug

The cable glands are used only for the introduction of fixed cables.

Please note the torques, cross sections and protection types of the screwed fittings in the following table.

Cable fittings

Type	Material	Id no.	EX-Labeling/Protection type	Cable cross-section for the sealing rings	SW	Torque / Sealant	
						Pressure screw	Fitting body
Standard:	Brass nickel-plated	55412	PTB 11 ATEX 1007 X IP66 / IP68 / IP69K	6-9 mm 9 - 14 mm	24 mm	10 Nm Silicone	
		59030	IMQ 08 ATEX 021 X IP66 / IP68	4 - 6 mm 6 - 9 mm 9 - 12 mm	22 mm	12 - 15 Nm Silicone	6 Nm Neopren
	Stainless steel	56086	PTB 11 ATEX 1007 X IP66 / IP 68 / IP69K	6 - 9 mm 9 - 14 mm	24 mm	10 Nm Silicone	
		59033	IMQ 08 ATEX 021 X IP66 / IP68 / IP69K	4 - 6 mm 6 - 9 mm 9 - 12 mm	22 mm	12 - 15 Nm Silicone	6 Nm Neopren
EMC	Brass nickel-plated	56091	PTB 11 ATEX 1007 X IP66 / IP 68 / IP69K	9 - 14 mm (7 - 12 mm guard)	24 mm	10 Nm Silicone	
		56092	IMQ 08 ATEX 021 X IP66 / IP68	4 - 12 mm (2 - 10 mm guard)	22 mm	12 - 15 Nm Silicone	6 Nm Neopren
Reinforced		56088	PTB 11 ATEX 1007 X IP66 / IP 68 / IP69K	9 - 14 mm (9 - 13 mm inside)	24 mm	10 Nm Silicone	
		56103		12 - 20 mm (10 - 15 mm inside)	30 mm	10 Nm Silicone	

End caps

Material	Id no.	Feature	SW	Torque
Brass nickel-plated	56093	PTB 09 ATEX 1002 X IP66 / IP68 / IP69K	22 mm	10 Nm Silicone
	59031	LCIE08 ATEX 6085 X IP66 / IP68 / IP69K	23 mm	6 Nm Neopren
Stainless steel	56094	PTB 09 ATEX 1002 X IP66 / IP68 / IP69K	22 mm	10 Nm Silicone
	59032	LCIE08 ATEX 6085 X IP66 / IP68 / IP69K	23 mm	6 Nm Neopren

5.5 Maintenance and Visual Inspection

For detectors that are used in hazardous areas, the detector housing (*Fig. 5-3*) and thus the pressure-proof enclosure of the electronics may be opened only by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES.

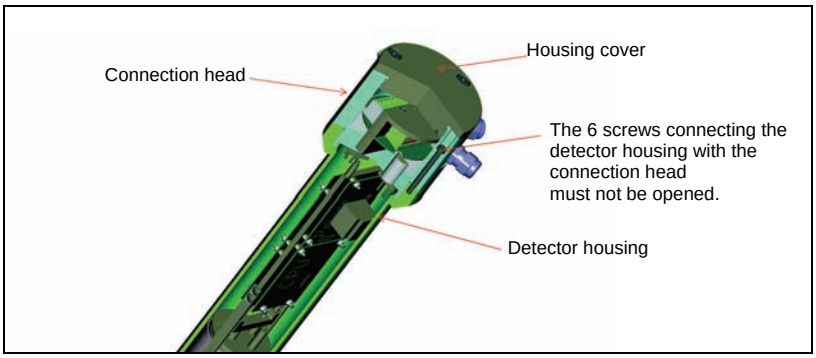

Housing cover
Connection head
The 6 screws connecting the detector housing with the connection head must not be opened.
Detector housing

Fig. 5-3 Detector housing with connection head

For commissioning, maintenance or repair, always use the checklists in *chapter 5.5.1* and *5.5.2* to document the accuracy and completeness of your work.

Visual inspection

Carry out regular visual inspections of the SENSseries measuring system, at least once every three years. To do this, use the visual inspection plan from *chapter 5.5.1*. Take appropriate actions immediately if you detect damage in the course of the visual inspection; if necessary, disconnect the detector from power supply immediately.

To determine the inspection intervals for the visual inspection, take the following conditions into consideration:

- ambient conditions (temperature, humidity, corrosive atmosphere, shock and vibrations)
- operating conditions (degree of utilization , operating errors)
- major changes in the overall system (e.g.changes in zoning)

Seals

If the cover or the housing is opened, check the respective seals and replaced them, if necessary.

Cleaning

Take care not to damage the cable glands and the type plates during cleaning. Remove coarse debris with a stainless steel wire brush. Grinding, filing or chipping away deposits with the hammer is not permitted.

5.5.1 Plan for Visual Inspection of the Detector

If you answer one of the following questions with "No", you have to record the action you have taken to remedy this deficiency in the last column. Make sure before you take the device into operation again that the provisions you have taken are correct by consulting with the person in charge of explosion protection.

Date: ..... Name:.....	Yes	No	Measures
General test			
Is the housing free of corrosion, dents, cracks, holes and warps?			
Is the housing cover of the detector firmly attached?			
Are the permissible temperatures observed in accordance with EN 60079-0?			
Are the external connections of the potential equalizer in good working order?			
Is the surface of the detector free of contact with other non-alloy steel parts?			
Are the connected cables mounted strain-relieved?			
Is a separator in place?			
Is the separator easily accessible for maintenance personnel?			
Test of screwed fittings			
Were only metallic fittings used?			
Are the screwed fittings suitable for the ambient conditions?			
Are screwed fittings used for the normal ambient temperature range between -20 °C and +40 °C that at least meet the standards specified on the cover page of the EC type-examination certificate or are screwed fittings used that have been approved for use in the LB 480 by BERTHOLD TECHNOLOGIES?			
Is the permissible temperature range of the screwed fittings suitable for the temperatures encountered?			
Are the screwed fittings suitable for the the required protection type (at least IP 65)?			
Are the screwed fittings free of corrosion?			
Test of screwed fittings			
Is more than one adapter (reduction or extension piece) used?			

Date: ..... Name:.....	Yes	No	Measures
Is the total length of the cable glands plus any possibly used adapters less than 10 cm?			
Are the cable diameters of the cables used permitted for the cable glands?			
Are the connected cable suitable for the ambient conditions?			
Are the connected cables suitable for a temperature which is 15 °C above the maximum ambient temperature?			
Are the screwed fittings undamaged?			
Are there any doubts concerning the sealing of the screwed fittings?			
Are the cables firmly clamped in the cable glands?			
Are the screwed fittings firmly tightened?			
Especially with pressure-resistant cable conduits (FM/CSA): Does the cable sealing ensure explosion protection?			
Are all unused openings provided with dummy plugs?			
Are the dummy plugs adequate for the required explosion group?			

5.5.2 Plan for Inspection of the Terminal Compartment

If you answer one of the following questions with "No", you have to record the action you have taken to remedy this deficiency in the last column. Make sure before you take the device into operation again that the provisions you have taken are correct by consulting with the person in charge of explosion protection.

Date: ..... Name:.....	Yes	No	Measures
General test			
Is the interior (terminal compartment) in perfect order?			
Is the interior dry, clean and free of foreign material?			
Are the cables connected firmly?			
Are the terminals in perfect order?			
Is the interior free of corrosion?			
Is the insulation free of damages or trails?			
Is the mechanical fastening of the fixtures in good working order?			
Has the device been installed according to instructions in accordance with EN 60079-14 ?			
Does the cable insulation extend up to the terminals or up to the ferrules?			
Does the collar extend into the terminal for all ferrules used?			
Are all the wires of a fine-wire strand covered by the terminal and clamped?			
Is the ground conductor properly installed?			
Is the screen properly insulated electrically (e.g. with shrink tubing)?			
Test of the condition of the gap preventing the transmission of the ignition on the cover of the Ex-d terminal compartment (Applies only to detectors with FM/CSA approval)			
Is the cylindrical fit (spark gap) on the cover or in the terminal compartment free from corrosion, damage and scratches?			
Is the spark gap free of foreign bodies?			
Leak test			
Is the sealing inside the screwed fittings OK?			
Is the sealing of the cover in the terminal compartment undamaged and free of cracks and settlement?			

5.6 ATEX Certificate

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

(1) **EC-TYPE-EXAMINATION CERTIFICATE**

(Translation)

(2) Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres - **Directive 94/9/EC**

(3) EC-type-examination Certificate Number:

PTB 11 ATEX 1032 X

(4) Equipment: Scintillation measuring unit of the LB 480 series

(5) Manufacturer: Berthold Technologies GmbH & Co. KG

(6) Address: Calmbacher Str. 22, 75323 Bad Wildbad, Germany

(7) This equipment and any acceptable variation thereto are specified in the schedule to this certificate and the documents therein referred to.

(8) The Physikalisch-Technische Bundesanstalt, notified body No. 0102 in accordance with Article 9 of the Council Directive 94/9/EC of 23 March 1994, certifies that this equipment has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of equipment and protective systems intended for use in potentially explosive atmospheres, given in Annex II to the Directive.

The examination and test results are recorded in the confidential test report PTB Ex 11-15268.

(9) Compliance with the Essential Health and Safety Requirements has been assured by compliance with:

EN 60079-0:2009 EN 60079-1:2007 EN 60079-7:2007 EN 60079-31:2009

(10) If the sign "X" is placed after the certificate number, it indicates that the equipment is subject to special conditions for safe use specified in the schedule to this certificate.

(11) This EC-type-examination Certificate relates only to the design, examination and tests of the specified equipment in accordance to the Directive 94/9/EC. Further requirements of the Directive apply to the manufacturing process and supply of this equipment. These are not covered by this certificate.

(12) The marking of the equipment shall include the following:

II 2 G Ex db IIC T1 - T6 or Ex db eb IIC T6

II 2 D Ex tb IIIC T80 °C

or

II 2 G Ex db eb IIC T1 – T5

II 2 D Ex tb IIIC T95 °C

ZSEx10100e.dotm

Zertifizierungssektor Explosionsschutz Braunschweig, April 23, 2012

On behalf of PTB:
(signature)
Dr.-Ing. U. Klausmeyer
Direktor und Professor

sheet 1/4

EC-type-examination Certificates without signature and official stamp shall not be valid. The certificates may be circulated only without alteration. Extracts or alterations are subject to approval by the Physikalisch-Technische Bundesanstalt.
In case of dispute, the German text shall prevail.

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Braunschweig und Berlin

(13) **SCHEDULE**

(14) **EC-TYPE-EXAMINATION CERTIFICATE PTB 11 ATEX 1032 X**

(15) Description of equipment

The scintillation measuring unit of the LB 480 series is part of a measuring system for monitoring industrial processes. It is used for continuously measuring the level in tanks or bins that contain liquid, granular, viscous or encrustation-forming media, and for measuring conveyor belt charges, and the density of liquids, suspensions, slurries and bulk solids. It is also used for continuously measuring level, weight per unit area, ash, sulphur, hydrogen and other specific application.

The measuring principle is based on the absorption of gamma rays. The radiation source does not form part of the measuring unit and is therefore not included in the above type approval either.

The field of application is the installation in zones 1 or 2 (dust: 21 or 22, resp.). The unit consists of a scintillation detector with the required analysing electronics, which are housed in one common enclosure.

The enclosure can be provided with a water-cooling system to be able to cool the electronics system.

Structure

The scintillation measuring unit consists of two compartments (terminal and pressure compartment) for which sealing units (O ring and flat seal) are used for compliance with IP66 / IP68 / IP69K protection requirements. The terminal compartment is designed for supply and signalling purposes and interface connection. The pressure compartment comprises the photo multiplier with downstream voltage divider/pre-amplifier board, signal processing board, CPU board, analog, digital and fieldbus interfaces, and the power supply modules.

Type code and versions

The different versions are distinguished by two characters (the small x in the version identifier is used as a wildcard character). The first numeric character distinguishes between the following detectors:

Version **A**x: rod detectors with plastic scintillator
Version **B**x: point detectors with NaI scintillator
Version **E**x: detectors with glass window for tower-sens or super-sens

The second numeric character distinguishes between different kinds of terminal compartments:

Version x**1**: flameproof enclosure-type terminal compartment
Version x**2**: increased safety-type terminal compartment

sheet 2/4

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SCHEDULE TO EC-TYPE-EXAMINATION CERTIFICATE PTB 11 ATEX 1032 X

LB 480 - . . - . . . - . . - ..-...-.	Version	Description
1 1	Bx	Point detector 50x50
1 2	Bx	Point detector 50x50 + water cooling
1 .	Bx	Point detector ...
2 A	Ax	Rod detector 500 mm
2 B	Ax	Rod detector 500 mm + water cooling
2 .	Ax	..
2 K	Ax	Rod detector 2000 mm
2 L	Ax	Rod detector 2000 mm + water cooling
3 1	Ex	Super-Sens
3 2	Ex	Super-Sens + water cooling
3 .	Ex	
4 1	Ex	Tower-Sens
4 2	Ex	Tower-Sens + water cooling
4 .	Ex	
0 0		Without Ex type approval
1	x = 2	ATEX Ex de (passive / slave)
2	x = 2	ATEX Ex de (active)
A	x = 1	ATEX Ex d (passive / slave)
B	x = 1	ATEX Ex d (active)
A		Ex revision
.		Ex revision
.		Signal output (Slave, HART, etc.)
1		Power supply: 24 VDC
2		Power supply: 100 - 240 VAC
		Not water cooled
		Water cooled

Protection and marking

Version	Marking in acc. with Directive 94/9/EC	Marking in acc. with Standards: • EN 60079-0: 2009 • IEC 60079-0: 2007	Permissible ambient temperature Enclosure inside bright / black
x1	⟨Ex⟩ II 2 G	Ex d IIC T1-T6 Gb	-40 °C ≤ T_a ≤ +60 °C
x2	⟨Ex⟩ II 2 G	Ex d e IIC T6 Gb	-40 °C ≤ T_a ≤ +65 °C
A2, B2	⟨Ex⟩ II 2 G	Ex d e IIC T1-T5 Gb	-40 °C ≤ T_a ≤ +80 °C
x2	⟨Ex⟩ II 2 D	Ex tb IIIC T80 °C Db	-40 °C ≤ T_a ≤ +65 °C
A2, B2	⟨Ex⟩ II 2 D	Ex tb IIIC T95 °C Db	-40 °C ≤ T_a ≤ +80 °C

The Ex version with the cemented glass window is qualified for temperatures up to T_a ≤ 70 °C.

(16) Assessment and Test Report PTB Ex 11-15268

sheet 3/4

EC-type-examination Certificates without signature and official stamp shall not be valid. The certificates may be circulated only without alteration. Extracts or alterations are subject to approval by the Physikalisch-Technische Bundesanstalt.
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SCHEDULE TO EC-TYPE-EXAMINATION CERTIFICATE PTB 11 ATEX 1032 X

(17) Special conditions

Repairs on flameproof joints may only be performed in accordance with the manufacturer's design specifications. Repair on the basis of the values in tables 1 and 2 of EN 60079-1 is not permitted.

Additional notes for safe operation:

Connection conditions

If the terminal compartment is of the flameproof enclosure type, the following requirements must be observed:

1. The scintillation measuring unit of the LB 480 series shall be connected with suitable cable glands or conduit systems that meet the requirements stipulated in EN 60079-1, sections 13.1 and 13.2, and for which a separate test certificate has been issued.
2. Cable glands (Pg type glands) and blanking plugs of a simple design must not be used. If the scintillation measuring unit is connected by means of a conduit entry fitting which has been approved for this purpose, the required sealing device shall be provided immediately at the enclosure.
3. Openings that are not used shall be sealed in compliance with the specifications in EN 60079-1, section 11.9.
4. If connection is made in the potentially explosive area, the connecting cables shall be connected in an enclosure that meets the requirements of an approved type of protection in accordance with EN 60079-0, section 1.

Components attached or installed (terminal compartments, bushings, Ex-type cable glands, connectors) shall be of a technical standard that complies as a minimum with the specifications on the cover sheet, and they shall have a separate examination certificate. The operating conditions specified in the component certificates must be complied with.

The connecting cables shall be of a quality that conforms with the thermal, chemical and mechanical requirements under field service conditions. The connecting cables shall be fixed and routed so that they will be adequately protected against damage.

The LB 480 scintillation measuring unit shall be included in the local equipotential bonding system.

These notes and instructions shall accompany each item of the electrical equipment in an adequate form.

(18) Essential health and safety requirements

Met by compliance with the afore-mentioned Standards.

Zertifizierungssektor Explosionsschutz Braunschweig, April 23, 2012
On behalf of PTB:
(*signature*)

Dr.-Ing. U. Klausmeyer
Direktor und Professor

4 pages, correct and complete as regards content.
On behalf of PTB:

Dr.-Ing. M. Thedens Braunschweig, June 20, 2012
Oberregierungsrat

sheet 4/4

EC-type-examination Certificates without signature and official stamp shall not be valid. The certificates may be circulated only without alteration. Extracts or alterations are subject to approval by the Physikalisch-Technische Bundesanstalt.
In case of dispute, the German text shall prevail.

Physikalisch-Technische Bundesanstalt • Bundesallee 100 • 38116 Braunschweig • GERMANY

5.7 IECEx Certificate

IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification Scheme for Explosive Atmospheres
for rules and details of the IECEx Scheme visit www.iecex.com

Certificate No.:	IECEx PTB 12.0038X issue No.:0	Certificate history:
Status:	**Current**	
Date of Issue:	**2012-07-26** Page 1 of 3	
Applicant:	**Berthold Technologies GmbH & Co. KG** Calmbacher Str. 22 75323 Bad Wildbad **Germany**	
Electrical Apparatus: *Optional accessory:*	**Scintillation measuring unit of the LB 480 series**	
Type of Protection:	**Ex d e, Ex t**	
Marking:	**Ex db IIC T1 - T6 or Ex db eb IIC T6** **Ex tb IIIC T80 °C** **Ex db eb IIC T1 – T5** **Ex tb IIIC T95 °C**	
Approved for issue on behalf of the IECEx Certification Body:	Dr.-Ing. Uwe Klausmeyer	
Position:	Head of department "Flame propagation processes"	
Signature: *(for printed version)*		
Date:	02. AUG. 2012	

1. This certificate and schedule may only be reproduced in full.
2. This certificate is not transferable and remains the property of the issuing body.
3. The Status and authenticity of this certificate may be verified by visiting the Official IECEx Website.

Certificate issued by:

Physikalisch-Technische Bundesanstalt (PTB)
Bundesallee 100
38116 Braunschweig
Germany

IECEx Certificate of Conformity

Certificate No.: IECEx PTB 12.0038X

Date of Issue: **2012-07-26** Issue No.: **0**

Page 2 of 3

Manufacturer: **Berthold Technologies GmbH & Co. KG**
Calmbacher Str. 22
75323 Bad Wildbad
Germany

Manufacturing location(s):

This certificate is issued as verification that a sample(s), representative of production, was assessed and tested and found to comply with the IEC Standard list below and that the manufacturer's quality system, relating to the Ex products covered by this certificate, was assessed and found to comply with the IECEx Quality system requirements. This certificate is granted subject to the conditions as set out in IECEx Scheme Rules, IECEx 02 and Operational Documents as amended.

STANDARDS:
The electrical apparatus and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards:

IEC 60079-0 : 2011 Edition: 6.0	Explosive atmospheres - Part 0: General requirements
IEC 60079-1 : 2007-04 Edition: 6	Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"
IEC 60079-31 : 2008 Edition: 1	Explosive atmospheres – Part 31: Equipment dust ignition protection by enclosure 't'
IEC 60079-7 : 2006-07 Edition: 4	Explosive atmospheres - Part 7: Equipment protection by increased safety "e"

*This Certificate **does not** indicate compliance with electrical safety and performance requirements other than those expressly included in the Standards listed above.*

TEST & ASSESSMENT REPORTS:
A sample(s) of the equipment listed has successfully met the examination and test requirements as recorded in

Test Report:
DE/PTB/ExTR12.0052/00

Quality Assessment Report:

DE/PTB/QAR06.0011/02

IECEx Certificate of Conformity

Certificate No.: IECEx PTB 12.0038X

Date of Issue: **2012-07-26** Issue No.: **0**

Schedule

EQUIPMENT:
Equipment and systems covered by this certificate are as follows:

The scintillation measuring unit of the LB 480 series is part of a measuring system for monitoring industrial processes. It is used for continuously measuring the level in tanks or bins that contain liquid, granular, viscous or encrustation-forming media, and for measuring conveyor belt charges, and the density of liquids, suspensions, slurries and bulk solids. It is also used for continuously measuring level, weight per unit area, ash, sulphur, hydrogen and other specific application.The measuring principle is based on the absorption of gamma rays. The radiation source does not form part of the measuring unit and is therefore not included in the above type approval either.The field of application is the installation in zones 1 or 2 (dust: 21 or 22, resp.). The unit consists of a scintillation detector with the required analysing electronics, which are housed in one common enclosure.The enclosure can be provided with a water-cooling system to be able to cool the electronics system.

Structure

The scintillation measuring unit consists of two compartments (terminal and pressure compartment) for which sealing units (O ring and flat seal) are used for compliance with IP66 / IP68 / IP69K protection requirements. The terminal compartment is designed for supply and signalling purposes and interface connection. The pressure compartment comprises the photo multiplier with downstream voltage divider/pre-amplifier board, signal processing board, CPU board, analog, digital and fieldbus interfaces, and the power supply modules.

CONDITIONS OF CERTIFICATION: YES as shown below:

Repairs on flameproof joints may only be performed in accordance with the manufacturer's design specifications. Repair on the basis of the values in tables 1 and 2 of EN 60079-1 is not permitted.

Annexe: Annex to IECEx PTB 120038X.pdf

Annex to IECEx PTB 12.0038 X

Type code and versions

The different versions are distinguished by two characters (the small x in the version identifier is used as a wildcard character). The first numeric character distinguishes between the following detectors:

Version **Ax**: rod detectors with plastic scintillator
Version **Bx**: point detectors with NaI scintillator
Version **Ex**: detectors with glass window for tower-sens or super-sens

The second numeric character distinguishes between different kinds of terminal compartments:

Version **x1**: flameproof enclosure-type terminal compartment
Version **x2**: increased safety-type terminal compartment

LB 480 - . . - . . - . . - ..-...-.	Version	Description
1 1	Bx	Point detector 50x50
1 2	Bx	Point detector 50x50 + water
1 .	Bx	Point detector ...
2 A	Ax	Rod detector 500 mm
2 B	Ax	Rod detector 500 mm + water
2 .	Ax	..
2 K	Ax	Rod detector 2000 mm
2 L	Ax	Rod detector 2000 mm + water
3 1	Ex	Super-Sens
3 2	Ex	Super-Sens + water cooling
3 .	Ex	
4 1	Ex	Tower-Sens
4 2	Ex	Tower-Sens + water cooling
4 .	Ex	
0 0		Without Ex type approval
1	x = 2	ATEX Ex de (passive / slave)
2	x = 2	ATEX Ex de (active)
A	x = 1	ATEX Ex d (passive / slave)
B	x = 1	ATEX Ex d (active)
A		Ex revision
.		Ex revision
.		Signal output (Slave, HART, etc.)
1		Power supply: 24 VDC
2		Power supply: 100 - 240 VAC
		Not water cooled
		Water cooled

Protection and marking

Version	Marking in acc. with Directive 94/9/EC	Marking in acc. with Standards: • EN 60079-0: 2009 • IEC 60079-0: 2007	Permissible ambient temperature Enclosure inside bright / black
x1	⟨Ex⟩ II 2 G	Ex d IIC T1-T6 Gb	-40 °C ≤ T_a ≤ +60 °C
x2	⟨Ex⟩ II 2 G	Ex d e IIC T6 Gb	-40 °C ≤ T_a ≤ +65 °C
A2, B2	⟨Ex⟩ II 2 G	Ex d e IIC T1-T5 Gb	-40 °C ≤ T_a ≤ +80 °C
x2	⟨Ex⟩ II 2 D	Ex tb IIIC T80 °C Db	-40 °C ≤ T_a ≤ +65 °C
A2, B2	⟨Ex⟩ II 2 D	Ex tb IIIC T95 °C Db	-40 °C ≤ T_a ≤ +80 °C

The Ex version with the cemented glass window is qualified for temperatures up to T_a ≤ 70 °C.

Additional notes for safe operation:

Connection conditions

If the terminal compartment is of the flameproof enclosure type, the following requirements must be observed:

1. The scintillation measuring unit of the LB 480 series shall be connected with suitable cable glands or conduit systems that meet the requirements stipulated in EN 60079-1, sections 13.1 and 13.2, and for which a separate test certificate has been issued.
2. Cable glands (Pg type glands) and blanking plugs of a simple design must not be used. If the scintillation measuring unit is connected by means of a conduit entry fitting which has been approved for this purpose, the required sealing device shall be provided immediately at the enclosure.
3. Openings that are not used shall be sealed in compliance with the specifications in EN 60079-1, section 11.9.
4. If connection is made in the potentially explosive area, the connecting cables shall be connected in an enclosure that meets the requirements of an approved type of protection in accordance with EN 60079-0, section 1.

Components attached or installed (terminal compartments, bushings, Ex-type cable glands, connectors) shall be of a technical standard that complies as a minimum with the specifications on the cover sheet, and they shall have a separate examination certificate. The operating conditions specified in the component certificates must be complied with.

The connecting cables shall be of a quality that conforms with the thermal, chemical and mechanical requirements under field service conditions. The connecting cables shall be fixed and routed so that they will be adequately protected against damage.

The LB 480 scintillation measuring unit shall be included in the local equipotential bonding system.

These notes and instructions shall accompany each item of the electrical equipment in an adequate form.

6 Electrical Installation

The electrical installation may be carried out only by a qualified electrician.

Electrical hazards

Danger to life due to electrical shock!

Open the housing only to perform installation, maintenance and repair work.

When the housing is open, you may come into contact with live parts if the power supply is connected. During installation and maintenance work on the hardware of the detector you have to switch off the measuring system, possibly connected relay contacts, and all the inputs and outputs in order to avoid contact with live parts.

Never modify the installation without having thoroughly read this User's Manual.

Cable glands, adapters and dummy plugs

The screwed fittings must be suitable for the intended use (ATEX or FM/CSA).

If the detector is not used in explosion hazardous areas, the screwed fittings, adapters and dummy plugs have to be tested in accordance with at least one of the following guidelines or standards:

– EN50262
– UL1565
– C22.2 No. 0.17.92
– ATEX

At ambient temperatures of -20 to +40°C, only metallic cable glands and metal adapters may be used to comply with the protection class IP 65. The material properties of the cable glands, adapters and dummy plugs used must be suitable for the ambient conditions existing at the measuring location.

At ambient temperatures above 40°C and below -20°C, only the cable glands tested and approved by Berthold may be used.

The tightening torques for the cable glands supplied by BERTHOLD TECHNOLOGIES are listed on *page 1-34*.

Please note that only one adapter per cable entry may be used. It is not permitted to screw together several adapters.

The total length of the cable glands, including any adapter must not exceed 10 cm.

Cable conduits that are not used must be closed by suitable, metallic dummy plugs.

Special cable glands are required for reinforced cables. The cable assembly is described in the installation instructions of the cable conduit used.

In case of doubt, we recommend using screw fittings, dummy plugs or adapters by BERTHOLD TECHNOLOGIES.

Cables and wires

Only use cables with diameters that are permitted for each cable gland. The cables must have the following wire cross-sections:

– Power cord: 1 mm^2 to 2.5 mm^2
– Signal lines: 0.5 mm^2 to 2.5 mm^2

The cables used must be suitable for at least a temperature which is 15°C above the maximum ambient temperature.

The cables must not be subjected to tensile stress, but have to be installed strain-relieved. We recommend creating a cable loop in front of the entry of the housing.

If there is a danger that the cable may be used as a stepladder, then the cables must be installed protected, for example in conduits. Also make sure that the cables that are connected to the detector are laid without abrasion or kinks.

Stranded lead

The ends of multi-strand wires or fine wire lines (strands) may not be tinned or soldered. Permitted variations are ferrules and direct connection of the strand.

IMPORTANT

When installing fine wire lines in a terminal, individual wires often get stuck at the edge of the terminal, are then pushed back and in the worst case project over the insulated edge of the terminal. Therefore, make sure that all multi-wire or fine wire lines are covered by the terminal and are clamped inside the terminal.

Grounding conductor

The grounding conductor has to be connected to the terminals marked with PE. With interconnected detectors (multi-detector operation) the PE may not be looped from one detector to another. Therefore supply lines with PE have to be guided in a star-shaped pattern from one terminal box to the individual detectors.

Potential equalization

Connect the detector to a equipotential busbar on site. The line on this bar must be as short as possible.

Separator

A separator

– must be present (regulation according to EN 61010-1)

– must be easily accessible for maintenance personnel

– has to be included in the company's internal documentation

It can be installed in the form of a circuit breaker or as a switch and must meet the requirements of IEC 947-1 and IEC 947-3. If a fuse is used, it must trigger only at a current of greater than 4 amps per unit.

General points that are important for installation

IMPORTANT

Open the terminal compartment in dry ambient conditions, not in the rain.
Moisture in the terminal compartment can both cause a short circuit with other lines or cancel the explosion protection.

- Please follow the signs on the detectors.
- Connect the cables with special care.
- The connecting cable and its installation must comply with applicable regulations.
- When installing the cable, make sure that mechanical damage to the conductor insulation from sharp edges or moving metal parts will be ruled out. If necessary, install the cable appropriately protected, for example in conduits.
- Install the connecting cables in the terminal compartment so that
  - dirt and moisture is avoided in the terminal compartment;
  - the wires are not damaged when stripping;
  - the conductor insulation or the collar of the ferrule extends into the housing of the terminal body;
  - bare conductive parts of the lines (e.g. small wires of a strand) do not protrude from the terminal body;
  - the length of the ferrule or the stripped wire can be 10 mm, so that the wire is securely held in the spring-type terminal;
  - if ferrules are used, the conductor insulation extends into the collar of the ferrule;
  - the minimum bending radii permitted for the respective cross-section are not fallen below;
  - install the cables strain-relieved and without abrasion.
- The SENSseries detectors may only be operated with fully closed housing.
- Cleaning corroded threads at the cable glands or cable conduits using abrasives or a wire brush is not allowed.
- The use of the detectors is not permitted if:
  - cable fittings are corroded or damaged;
  - threads on the housing are corroded or damaged;
  - dummy plugs are badly corroded or damaged;
  - the housing of the detector is badly corroded or damaged;
  - seals are damaged, show visible aging, or reduction.

7

Visual Inspection

Regular visual inspections of the measuring system SENSseries have to be carried out, at least once a year. To do this, use the visual inspection plan on *page 1-36*. Take appropriate actions immediately if you detect damage in the course of the visual inspection; if necessary, disconnect the detector from power supply immediately.

To determine the inspection intervals for the visual inspection, take the following conditions into consideration:

– Ambient conditions (outdoor, rain, sunlight, heat and cold).

– Operating conditions (utilization of system, operating errors)

– Measuring system is operated within or outside of an explosion hazardous zone.

Carry out a visual inspection before first commissioning and after any repair that requires opening of the detector cover and check the terminal compartment. Please use the visual inspection plan (*Volume 1*) on *page 1-36* and the plan for checking the terminal compartment on *page 1-38*.

8 Radiation Protection

8.1 General Information and Guidelines

In order to prevent adverse health effects caused by working with radioactive substances, limits for the maximum permissible radiation exposure of operating personnel have been agreed upon on an international level. Appropriate measures in designing the shieldings and arranging the measuring system at the measuring site will ensure that the radiation exposure of the personnel will remain below the maximum permissible value of 1mSv (100mrem) per year.

To ensure safe operation and compliance with the legal regulations, the company has to appoint a Radiation Safety Manager who is responsible for all questions relating to radiation protection. The Radiation Safety Officer will monitor handling of the radiometric measuring system and, if necessary, formalize the safeguards and any special precautions applicable to a given establishment in formal procedural instructions, which in special cases may serve as a basis for radiation protection guidelines. Radiation protection zones outside the shielding must be – if they are accessible – marked and guarded. These instructions should also include checks of the shutter device of the shielding and actions in case of accidents – such as fire or explosion. Any special event has to be reported to the Radiation Safety Manager immediately. He will then investigate any damage and immediately take suitable precautions if he detects defects that may adversely affect the safe operation of the system.

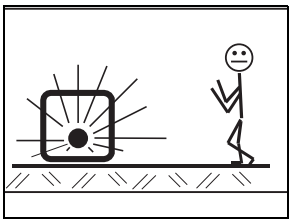
The Radiation Safety Manager has to make sure that the provisions of the Radiation Protection Regulations are observed. In particular, his duties include instructing the staff on the proper precautions when working in the vicinity of radioactive substances.

Radioactive sources that are no longer in use or have reached the end of their service life must be returned to the national radioactive waste disposal center or to the manufacturer.

Generally, every member of staff should endeavor to minimize any radiation exposure—even within the permissible limits—by careful and responsible action and by observing certain safety standards.

The total sum of the radiation dose absorbed by a body is determined by three factors. On the basis of these factors, certain fundamental radiation protection rules can be derived: Distance, time and shielding.

Distance

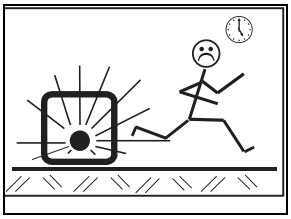


This means the distance between the radioactive source and the human body. The radiation intensity (dose rate) decreases – like light – in proportion to the square of the distance, i.e. doubling the distance to the source reduces the dose rate to one quarter.

Conclusion:

Maximum distance should be maintained when working in the vicinity of equipment containing radioactive material. This is especially true for persons that are not directly involved in this work.

Time

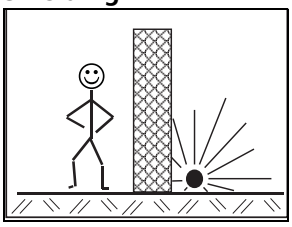


The total time a person stays in the vicinity of a radiometric measuring system and the body is exposed to radiation. The effect is cumulative and increases therefore with the duration of the radiation exposure.

Conclusion:

Any work in the vicinity of radiometric measuring system must be prepared carefully and organized such that it can be carried out in the shortest time possible. Having the proper tools is of particular importance.

Shielding



The material surrounding the source provides the shielding effect. As the shielding effect depends, following an exponential function, on the product of thickness multiplied by the density, it follows that materials with a high specific weight are to be used for shielding purposes. The device designer usually calculates suitable dimensions.

Conclusion:

Before mounting or dismounting the shielding, make sure that the radiation exit channel is *locked* in the closed position.

During use

Installation, dismantling, relocation, maintenance, testing involving the radioactive source and its shielding shall ONLY be performed under the supervision of the Radiation Safety Officer.

For more information please contact BERTHOLD TECHNOLOGIES.

8.2 Mounting the Shielding

8.2.1 Safety Instructions

The shielding container consists of a lead-filled, stable cast housing. A rotary shutter is installed to close the radiation exit channel. Operation is carried out from behind by a T-handle, which is secured by a padlock in open as well as in closed position. The locking prevents that the radiation path can be closed or opened by unauthorized persons. Also is prevents that unauthorized persons can remove the source.

Radiation exposure during installation

To keep the radiation exposure of the assembling personnel as low as possible, only licensed personnel who have been trained on how to handle radioactive substances are allowed to assemble or disassemble the shielding with the source. The work is performed according to the instructions and under the supervision of the Radiation Safety Manager. It has to be ensured that the lock of the shielding is closed and secured, so that no unshielded radiation can exit. Make sure the shielding is not modified or damaged.

Vibrations

Constant vibrations can loosen the lead in the shielding and grind up lead in extreme cases. In this case, the shielding effect and the function of the shielding are no longer guaranteed. In the worst case, the radioactive substance may leak out. Also, constant vibrations can loosen the source holder or the source, which also would impair both the function and the shielding effect.

A corrosive atmosphere requires an additional protective covering made from a suitable material, such as stainless steel sheet, or the shielding itself must be made from a suitable stainless steel. Corresponding versions are available on request from BERTHOLD TECHNOLOGIES.

NOTICE

Depending on the operation conditions, the function check has to be repeated at appropriate intervals, at least once a year.

8.2.2 Radiation Exposure during Installation of the Shielding

The shieldings of measuring systems are usually designed such that the limit of the control area is in a given distance (in most cases less than one meter) around the shielding, and it does not matter whether point or rod sources are being used and how high their activity is. A simplified calculation of the radiation exposure during installation of the shielding is possible with sufficient accuracy using the dose rate data printed on the type plate, measured in 1 m distance from the shielding. The radiation exposure D can be calculated according to the following formula:

$$D = DR \times t \times 4$$

D = accumulated dose during assembly in Sv
DR = dose rate on the type plate of the shielding in µSv/h
t = time needed for the installation with shielding in h

If the work process is prepared well, you may expect a working time of less than 20 minutes to perform work such as installation of the shielding or operating the shutter.

Calculation example

DR = 3µSv
t = 20min (1/3h)

$D = 3 \times 1/3 \times 4 = 4\mu Sv/h$

If we compare this dose with the permissible annual dose of 1 mSv for persons who are not exposed to radiation on their job, this work may be carried out 250 times per year by one and the same person.

8.2.3 Radiation Dose Calculations

When preparing work on radiometric measuring systems, it is important to pre-calculate the radiation exposure to be expected, since this has consequences on the required safety precautions.

The expected radiation exposure can be calculated quite easily and with sufficient accuracy, provided you know the isotope and the activity of the source used. You can take this information from the source documentation, or from the type label on the shielding.

The radiation exposure to be expected for a shielded source is calculated as follows:

$$\text{Dose } D = \frac{A \times k \times T}{r^2 \times s}$$

A is the activity of the source and k the respective specific Gamma radiation constant (see table below). The distance from the measuring point to the source is r and the duration of stay at this point is T. s is the shielding factor of the shielding used, which is indicated on the information sheet of the shielding or which can be calculated. It is listed in the shielding brochure or can be calculated. s = 1 when calculating the dose rate for work with an unshielded source.

Nuclide	k	Dimensions
Co-60	0.35	$\frac{\mu Sv \times m^2}{h \times MBq}$
Cs-137	0.09	

Calculation example

Calculate the dose in a distance of 50 cm from a Co-60 source with an activity of 350 MBq and a time of 30 minutes. The source is installed in a shielding with a shielding factor of 30:

$$\text{Dose } D = \frac{350MBq \times 0.35\mu Sv \times m^2 \times 0.5h}{(0.5m)^2 \times h \times MBq \times 30} = 8.2\mu Sv$$

8.3 Testing the Shutter Mechanism

The Radiation Protection Ordinance requires that regular functional testing and maintenance are carried out on the shielding and the inspection is documented. In establishing the testing interval for periodic functional testing and maintenance of the source shielding, the ambient and operating conditions of the measuring device, the legal regulations and the permit conditions must be considered. The functional checks and maintenance have to be carried out, however, at least once a year.

The functional test is to ensure that the locking mechanism is working properly. It must be ensured that:

- the closure moves easily and freely
- the locking mechanism does not get jammed at any point in the range of rotation

▶ the beam path can be closed completely

If you notice a failure or you have doubts, please contact the BERTHOLD TECHNOLOGIES service department.

8.4 Safety Measures

When designing the installation of radiometric measuring systems, the possibility that a fire breaks out must be considered. Flammable substances must not be stored in the proximity of radioactive substances. They should be covered and protected properly to prevent a possible spreading of the fire to the radioactive sources. It is mandatory to coordinate all preventive measures against fire with the local authorities, primarily with the fire department, which must be informed about the type, scope and place of application of the radioactive substances used, in order to be prepared in the event of fire.

When devising alarm plans, possible special features of the radiometric measuring system have to be mentioned; the Radiation Safety Manager to be notified in the event of an emergency has to be included in those plans as well, and also the address and phone number of the regulatory authority.

8.5 Protection against Theft

Radioactive substances or facilities containing radioactive substances must be secured against unauthorized use. Fixed installations are, by their nature, protected against unauthorized use.

If facilities working with radiometric measuring systems are taken out of service for a longer or indefinite period of time, the radioactive sources together with their shieldings should be dismantled and secured until the facility is taken into operation again.

Portable measuring systems, on the other hand, have to be protected by keeping them under constant supervision, or, if they are not in operation, by keeping them in a locked room or container which can be guarded against unauthorized access.

This is especially true for low activity test sources which are used, for example, to check the function of dose rate measuring instruments.

In the event that radioactive substances are lost, the Radiation Safety Manager and the regulatory authority have to be notified immediately.

In case of theft, the police must be informed as well.

8.6 Accidents, Loss, Damage, Fire, Theft

Remember the principles of health and safety in such situations: Time, distance, and shielding (see also *page 1-55*). In case of one of the above situations:

- Limit access to the area

- Report the incident to the authorities.
- Inform BERTHOLD TECHNOLOGIES.

Proper handling and disposal of possibly leaking radioactive sources or contaminated parts of the equipment must be coordinated with the supervisory authority.

8.6.1 Malfunctions and Accidents

The Radiation Protection Ordinance defines malfunction as an event which for safety reasons prohibits continuation of the operation of the facility.

Malfunction

Malfunction means, that a device necessary to guarantee safe operation of the facility, e.g. the seal of the active radiation beam of the shielding, no longer functions properly.

Accident

An accident is an event which could expose persons to a radiation dose which exceeds the permissible limits, or could cause contamination by radioactive substances.

In terms of safety, malfunctions and accidents are very serious events and appropriate steps must be taken immediately to prevent hazards to persons as well as facilities, or to reduce them as much as possible.

It is therefore important that the personnel is aware of preventive measures and is prepared for possible accidents or malfunctions of the facilities, so that dangerous consequences can be ruled out as far as possible by a proper reaction of the personnel.

In any case, the Radiation Safety Manager who checks the situation at site and takes all necessary steps to prevent unnecessary radiation exposure of the personnel must be notified immediately.

The Radiation Safety Manager will then take appropriate measures and will inform the official authority concerned, and, if necessary, get further information from the manufacturer.

IMPORTANT

The recovery of shieldings and sources after incidents and accidents may only be carried out in accordance with the instructions by the authorities.

The necessary steps should be taken in the following order:

- Locate source.
- Check function of shielding
- Check effectiveness of shielding by measuring the dose rate
- Guard and mark controlled areas.
- Secure source and shielding.
- Document the incident and assess possible radiation exposure of personnel.

In case the source capsule is damaged, the following points have to be considered:

- Avoid contamination.
- Handle source with tools (e.g. pincers or tweezers) and put both (source and tool) in a plastic bag.
- Stay behind auxiliary shielding (e.g. concrete, steel, or lead plate).
- Check if vicinity is free of contamination
- Secure radioactive waste properly (deposit at governmental collection site or return to manufacturer).

If the source is leaking and the dose rate might possibly be exceeded, the regulatory authority (e.g. trade board) has to be notified immediately.

In case of an accident or malfunction or any other event which affects the safety, the regulatory authority has to be informed and also, if necessary, the authority in charge of public safety. Please contact BERTHOLD TECHNOLOGIES if you need any further information.

8.7 Shielding and Source

Shieldings do not include any wearing parts or mechanically moving parts that under normal operating conditions require maintenance. For safety reasons, however, it should be possible any time to lock the useful beam. A functional check has to be performed in appropriate intervals of max. one year (see *chapter 8.3*). The Radiation Safety Manager has to be informed immediately if any faults on the shielding or a sluggish locking mechanism are detected. If the problem cannot be solved simply by cleaning, you have to stop working with the system until it has been repaired.

As long as the shielding does not show any significant mechanical damage or strong corrosion, the built-in source will be protected. Please observe the radiation protection guidelines when checking or replacing the source.

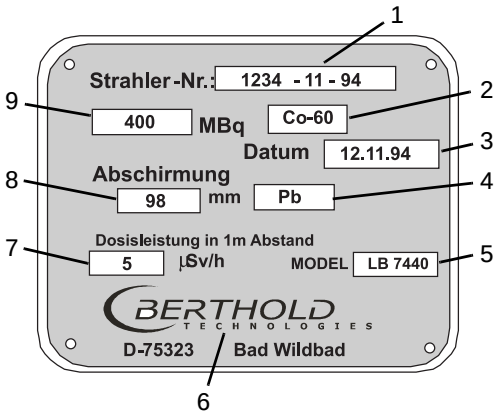
The radioactive sources used and the function area of the measuring system typically permit a service life of more than 10 years. The useful life of radioactive sources should be based on the period of use recommended in the leak test certificate. A source may have to

be replaced earlier if the statistical variations which increase in the course of time become intolerably high and any compensation by increasing the time constant is not acceptable any more, e.g. for control-engineering reasons.

IMPORTANT

Empty calibration has to be performed any time a source is replaced!

For information on the design of source and shielding please refer to the technical documentation and the identity plate (*Fig. 8-1*).



1 Source number
2 Isotope
3 Source manufacturing date
4 Shielding material
5 Type of shielding
6 Shielding manufacturer
7 Dose rate in 1 m distance
8 Effective shielding thickness
9 Activity

Fig. 8-1 Identity plate

If the source has to be renewed, you have to include the source number of the original source in your new order. This number consists of three digits, for example:

1234 - 11 - 94

The first group is a consecutive number, the second group identifies the month (here: November) and the third the year the source was manufactured (here: 1994). It is included on the identity plate of the shielding and also on the leak test certificate that comes with every source.

8.8 Leak Test

Depending on the stipulations of the regulatory authority responsible for the sources employed in their territory, regularly recurring leak tests have to be carried out. These tests have to be carried out by approved experts, or in consultation with the regulatory authority, by the manufacturer. The appropriate documents on the source have to be provided in order to carry out this test.

8.8.1 Required Documents

- Inventory of the sources to be tested with information on the previous leak tests
- Source certificate including the following information:
  - Nuclide, activity, purchase date, physical-chemical form
  - Description of capsule and type of sealing
  - Resistance against mechanical and thermal influences or classification of the source design
- Information on location, intended use as well as on the typical operational maximum mechanical and thermal stress.
- If the sources are installed in an appliance, a drawing has to be enclosed which clearly shows the position of the source and of all parts that are essential for its protection against external influences. Proposals for the best test method should be available, e.g. through information on alternative test areas and, if necessary, the required manipulations, how the test can be carried out without adversely affecting the workability of the system or appliance.
- Certificate on an acceptance test by the manufacturer.

Alternative test areas

For point source shieldings LB 744X

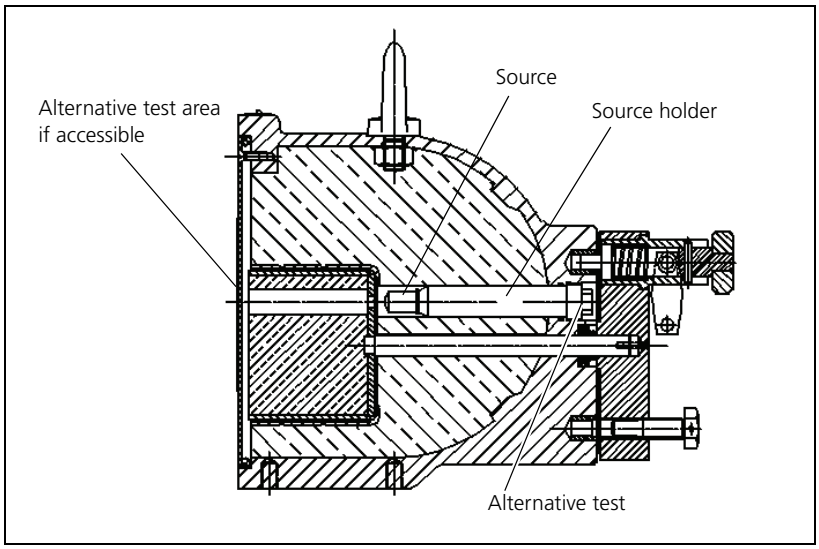


Fig. 8-2 Alternative test area on point source shieldings:

Turn lever to horizontal position for inspection.

The alternative test area is the head of the visible edge of the source holder. If the cover is also accessible then you have to wipe there as well.

9 Source Replacement

IMPORTANT
Radioactive sources may be replaced only by a competent firm that has a service license to handle radioactive materials.

9.1 Radiation Exposure during Source Replacement

It is important to calculate the possible radiation exposure even before mounting or dismantling point sources. An exact calculation is possible using the equation described in *chapter 8.2.3*.

The anticipated working hours should be split up in work in the direct vicinity of the shielding during mounting and dismantling the source holders and work with the unshielded source while fixing and dismantling the source and the source holder. The dose obtained while working in the vicinity of the shielding and the dose obtained while working with the unshielded source have to be calculated separately and added up.

A rather simplified estimation is possible, provided the work is prepared well. Based on the assumptions of a mean distance of 0.5 m for the whole body radiation and the time you are working with the unshielded source of 6 minutes (= 1/10 hour), the radiation exposure can be calculated for different activities (A) as follows:

Dose D = A x 0.15 for Co-60

Dose D = A x 0.04 for Cs-137

Enter the activity in MBq; the dose is calculated in µSv.

IMPORTANT
Using a pocket dosimeter with direct reading, measure the accurate radiation exposure during this work, even if the radiation exposure lies below the detection limit of dosimeters.

Calculation example

A point source with an activity of 400 MBq (approx. 11 mCi) has to be replaced. Using the above assumptions concerning distance and time and the above equation, we get the following result:

D = 400 x 0.15 = 60µSv

The radiation exposure in the vicinity of the shielding was previously calculated to be 10 µSv. The total radiation exposure including mounting and dismantling can then be estimated as being 70 µSv for a single part source.

If the above assumptions do no apply, the calculations have to be corrected accordingly. Actually, it can only be another working time which has a proportional effect on the result of the calculated dose rate.

9.2 Point Source Replacement on LB 744x Shieldings

In this chapter we will describe how to replace point sources on the following shieldings:

– LB 7440
– LB 7442
– LB 7444
– LB 7445
– LB 7446

The exchange of radioactive sources must be performed in accordance with applicable regulations under the supervision of the Radiation Safety Officer.

⚠ CAUTION

Health hazards due to radiation!

When replacing a source, you have to work with the unshielded source for a short time. An increased dose of radiation is harmful to health.

You have to carry a pocket dosimeter during work to measure the personal dose and to document the actual radiation exposure. Moreover, work has to be coordinated with the competent Radiation Safety Manager.

IMPORTANT

For Germany you have to keep in mind:
Source replacement by the customer is possible only if:
1) the appropriate technical qualification is guaranteed
2) the work to be done to replace the source has been approved explicitly by the regulatory authority. Your "License to Handle Radioactive Substances" states whether you are in possession of such a license.

Point sources have to be fixed on source holders which are then screwed into the shielding, positioning the source in the center of the shielding.

Prerequisite for this work is detailed knowledge of the design of the shielding; appropriate drawings must therefore be available.

Preparation

All necessary work has to be prepared well so that it can be carried out quickly to keep exposure to the unshielded source to a minimum. Using a drawing of the shielding, you should plan the best procedure and have the following tools handy:

- Allan keys in the required sizes.
- 2 pairs of pliers to take hold of source and source holder (e.g. a pair of combination pliers or multigrip pliers).

Cordon off an area consistent with the activity of the source. Prevent persons from approaching.

If sufficient space is available, the source can be replaced in the shielding installed at the measuring site. Move the new source in its transport shielding close to the installation site.

Prepare a suitable, clean space, if possible with an auxiliary shielding (shielding vessel, lead bricks, concrete stones, etc.) and place the source holder and the source there on a piece of paper to protect it against dirt.

Depending on the construction, you either have to open the lock on the shielding and turn the lever to center position between ON and OFF until the hexagon head bolt of the source holders becomes visible, or remove the locking plate, so that you can unscrew the source holder.

Source Replacement Procedure

▶ Open the lock (2) of the shielding (1).

▶ If necessary, pull out the locking screw (5) from the lever.

▶ Pull the knob (3) and turn the lever (4) by 90° to the right to the center position between OPEN and CLOSED

Now the hex screw head of the source holder is visible.

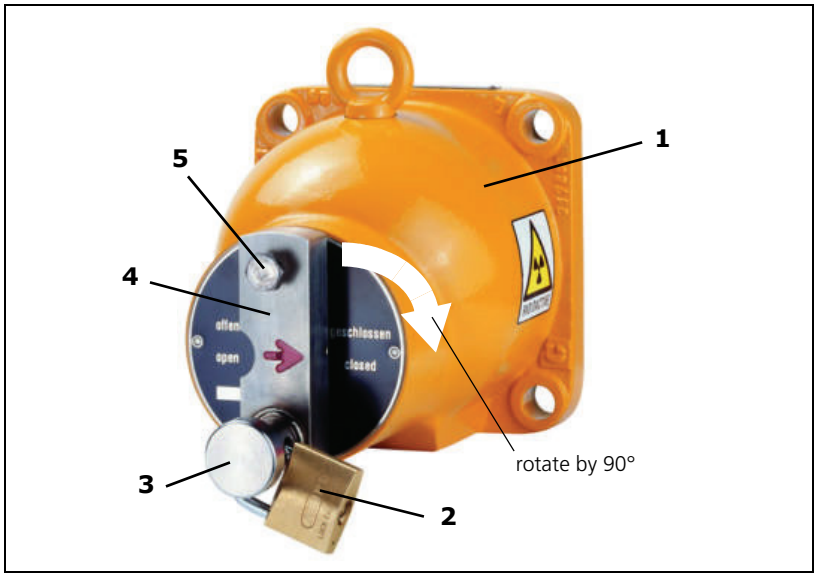


Fig. 9-1 Point source shielding, beam path closed

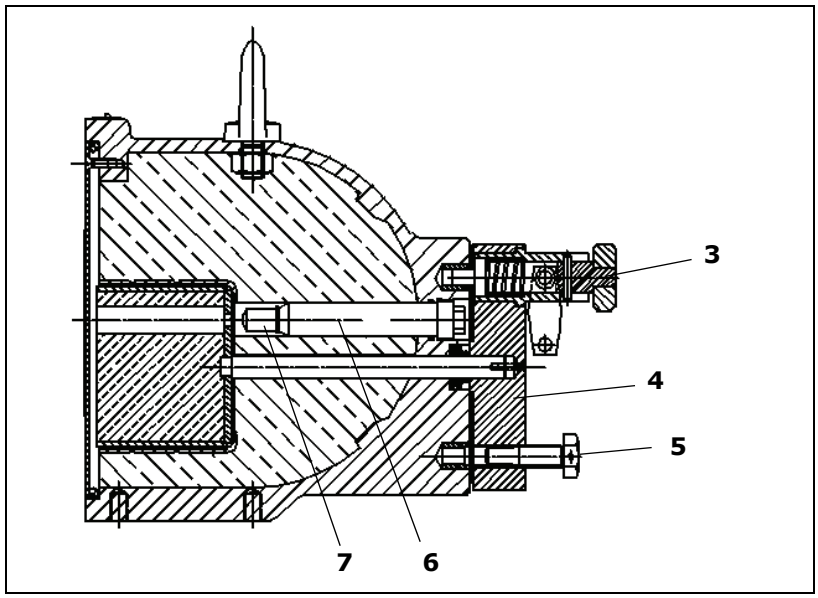


Fig. 9-2 Sectional drawing of source holder, beam path open

⚠ CAUTION

Health hazards due to radiation!

Do not remove the source from the shielding!

Do not touch the source to prevent a high partial body dose. Touch the source only with a tool that allows you to hold the source easily and safely. Keep the source far away from your body and set it down behind an auxiliary shielding.

- ▶ Screw the source holder (6) together with the source (7) using a socket wrench (size 12 mm).

Remove source from shielding

- ▶ Unscrew the source from the source holder using a socket wrench (size 10 mm). Hold the source holder using a second socket wrench (size 12 mm).

IMPORTANT

For this work, you should use the shielding housing as auxiliary shielding between source and body.

- ▶ Take hold of the source using a pair of pliers and immediately put it into the transport shielding or another shielding.

IMPORTANT

Make sure the source is not mixed up with the new or another source.

- ▶ If necessary, clean and grease the thread on the source holder and the shielding.

Install new source

- ▶ Using a pair of pliers, take the new source out of the transport shielding and firmly fix it onto the source holder together with the locking washer (torque: 3.5Nm).
- ▶ Put the source holder with the source again into the shielding and fix it using the socket wrench (torque: 44Nm).
- ▶ Check the proper ON/OFF function.
- ▶ Carefully close the transport shielding again, after you have put the old source into the transport shielding.

Replace the type label

- ▶ Replace the type label on the shielding or attach the new source number.
- ▶ Calibrate the system new (see *Volume 3*)

IMPORTANT

The special regulations regarding labeling and transport of the shielding back to the manufacturer have to be observed. If in doubt, please contact BERTHOLD TECHNOLOGIES's Source Transport Manager.

This completes the point source replacement.

10

Source Disposal

In general, each country has a collection site for radioactive material.

However, if you would like to return radioactive material to us for disposal, **the international regulations, ADR und GGVSE**, for transport, labeling and dose rates of the radioactive material have to be complied with, as well as the regulations of each country. It is the full responsibility of the sender to make sure these regulations are complied with.

Please keep in mind:

- Dose rate on the surface of the packing: < 2000 µSv/h.
- Dose rate in a distance of 1 m from the surface of the packing: < 100 µSv/h.
- Attach the UN number with the symbol for dangerous cargo on each package
- Shipping documents with correct description of the contents and accident procedures sheet in conformance with the ADR regulations are required.
- Packaging must comply with the valid ADR regulations.

For all questions on source transport or source return please contact our sales force, or our representative.

IMPORTANT

In many countries the transport of radioactive materials is subject to approval by the authorities. The source may be returned only after prior order confirmation and release confirmation by BERTHOLD TECHNOLOGIES.

Please keep in mind:

- Radioactive materials and their shieldings may not be damaged in any way and must have a valid seal test certificate. The seal test certificate may not be older than six months at the time of arrival in Germany. An exception is possible if a PTB certificate is available which confirms that the validity of the test dates has been extended.
- If you plan to return radioactive sources with isotope Am-241 or Cm-244, you have to include the *Special Form* certificate.
- It is indispensable that radioactive material that is returned to us is adequately labeled with your name and address.
  If you have received a quotation from us, please include our quotation number as well.
- Radioactive material can be returned only after you have received permission from BERTHOLD TECHNOLOGIES. We would be happy to send you a quotation on the costs to be expected for returning a source.
- The source return declaration and the seal test certificate have to be sent to BERTHOLD TECHNOLOGIES together with your order documents. You will get the form for the source return declaration from BERTHOLD TECHNOLOGIES on request.
- The source return declaration and the seal test certificate have to be sent to BERTHOLD TECHNOLOGIES together with your order documents. You will get the form for the source return declaration from BERTHOLD TECHNOLOGIES on request.

Notes:

Subject to change in the course of further technical development.

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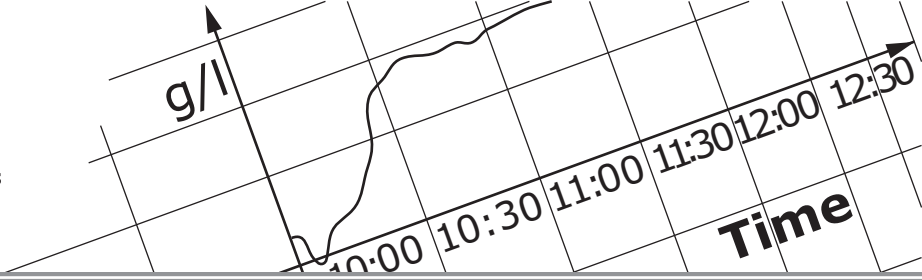


Volume 2 Installing SENSseries

1 System Description

1.1 Measuring System

1.1.1 Basic measuring configuration

The measuring system SENSseries LB 480 is a detector which, depending on its design, can be used for different measurement tasks:

– Level measurement

– Monitoring limit values

– Density measurement

The measuring system SENSseries LB 480 comes in the following versions:

– Point detector CrystalSENS (NaI 50/50)

– Point detector SuperSENS (scintillator 150/150)

– Rod detector UniSENS (length 0.5 to 2 m in 50 cm increments)

– Rod detector TowerSENS (length 3 to 8 m in 1 m increments)

The measuring system utilizes the radiometric measuring method, i.e. the absorption of Gamma radiation passing through the product being measured. In order to obtain an optimum measuring effect at minimal source activity, the ideal measuring geometry is calculated for each measuring site and the source is designed accordingly.

The measuring system SENSseries LB 480 is a compact detector, including the required components scintillation counters, power supply and the entire evaluation electronics, in one device.

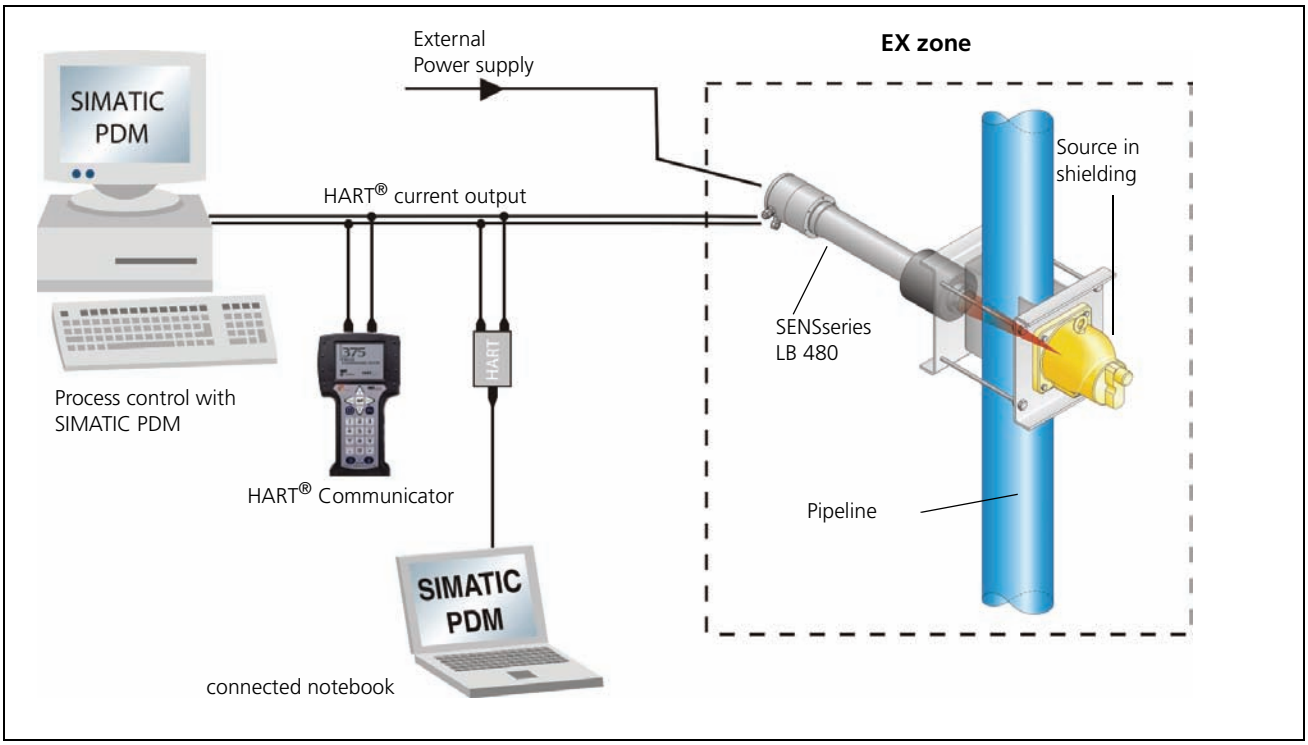


Fig. 1-1 Basic measuring configuration

1.1.2 Detector communication

Communication with the PCS[1]

The communication with display, evaluation and control devices takes place via a 2-wire HART® current interface with modulated digital current signal (FSK-modulation of the current signals according to the Standard Bell-202).

The density data are supplied as isolated 4-20 mA current signal to the process control system PCS.

Configuration and monitoring

Configuration, parameter setting and calibration of the detectors, as well as the output and display of the digital units of measure are carried out either:

- via a hand-held terminal, e.g. the 375 Field Communicator by Emerson Process Management GmbH & Co. OHG, or
- via PC and a suitable user interface for the detector, e.g. the SIMATIC PDM software.

Volume 3 describes the operation with HART® Communicator.

1. PCS = process control system

1.1.3 Measuring Geometries

The hardware and software of the measuring system SENSseries LB 480 allow for an easy adaptation of the system to different measuring geometries and measuring tasks. Therefore, the settings and parameters of the measuring device have to be defined with care during commissioning for the particular measuring task.

Commissioning log

Important parameters may not be changed during operation. The system must be taken into operation and settings changed only by persons who know how to work with the device. Therefore, all users should read these User's Manual carefully. BERTHOLD TECHNOLOGIES, therefore, recommends documenting all settings in a setup protocol.

Project planning

The best system configuration is selected for each measuring task in the planning stage. Therefore, the specific project documentation has to be observed and followed.

1.2 SENSseries Hardware

1.2.1 Detector

The measuring system SENSseries LB 480 comprises one detector and the evaluation unit, both accommodated in a sturdy stainless steel housing.

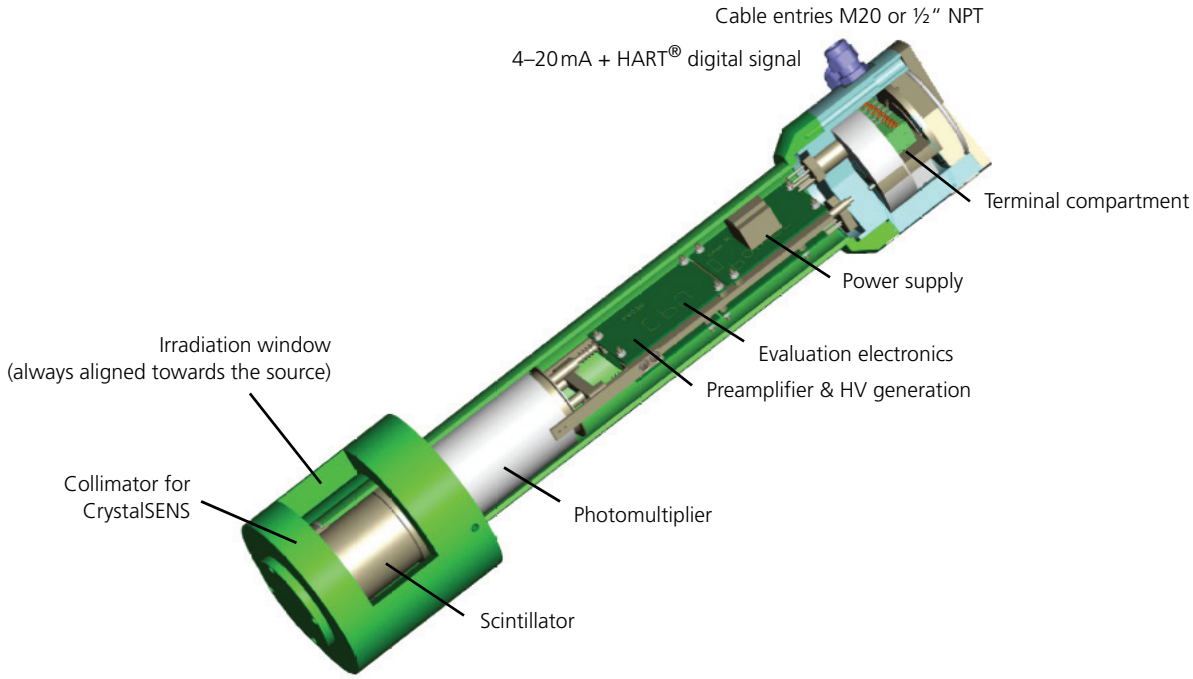


Fig. 1-2 Design of the SENSseries LB 480

Component	Description
Scintillator	Detecting Gamma radiation.
Photomultiplier, preamplifier, HV generation and evaluation electronics	Conversion of the flashes of light into electrical signals, conversion to liquid level, density or limit value.
Power supply	Power supply unit in two versions: 100V to 240V_{AC} 24V_{DC}
Terminal compartment	Includes all terminals which are necessary for the installation of the detector. For detailed information please see in *chapter 3* on *page 2-115*.
Thread of the cable entries	4 pcs M20 (ATEX) or 4 pcs ½" NPT (FM/CSA) for feedthrough of the connection cable.

Evaluation electronics

Control and processing of the signals are carried out by the evaluation electronics. The 4-20 mA measuring signal is passed through a 2-wire cable to the PCS (terminals 15 and 16).

Detector Communication

The measuring system SENSseries LB 480 uses the HART® protocol for communication. Configuration, parameter setting and calibration of the detectors, as well as the output and display of the digital units of measure are carried out either:

- via a hand-held terminal, e.g. the *375 Field Communicator* by Emerson Process Management GmbH & Co. OHG, or
- via PC with FDT frame application or
- via PC and the *SIMATIC PDM* software.

Access to electronics

At the top, the detector is closed by a detachable housing cover which can be removed by unscrewing the Allen screws.

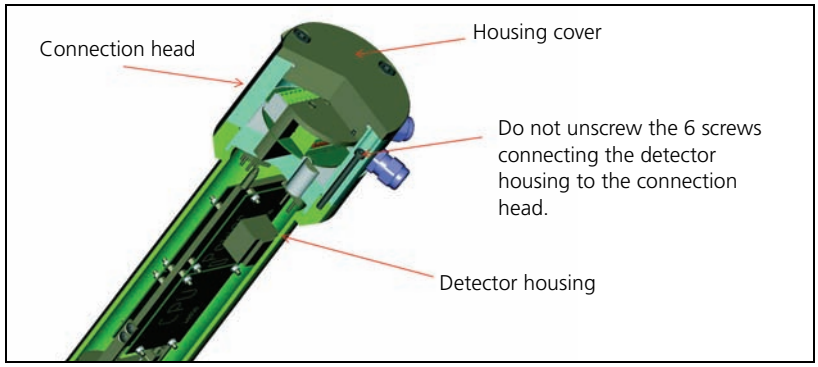

Connection head
Housing cover
Do not unscrew the 6 screws connecting the detector housing to the connection head.
Detector housing

Fig. 1-3 Detector housing with connection head

Decay compensation

For automatic decay compensation, the detector is equipped with a capacitor-buffered real-time clock. The capacitor buffers the real-time clock for about one week. If the buffering is lost, the real-time clock starts with the last saved date the detector was supplied with power. A message informs you that the date has to be updated.

1.2.2 Sources

Sources are not part of the SENSseries LB 480 measuring system. They can be purchased separately through BERTHOLD TECHNOLOGIES together with the respective shieldings and holding devices.

Radioactive sources for industrial applications are always "encapsulated radioactive substances" which are tightly welded into a sturdy capsule made of titan or stainless steel, so that the radioactive substance cannot leak out. Contamination is therefore ruled out. Moreover, any activation of the product being measured by the sources used is not possible for physical reasons.

The following radiation sources are used for measurement:

- *Co-60* emits Gamma radiation with an energy of 1.17 or 1.33MeV. It is available as rod or point-shaped source. The influence of interferences due to gas density fluctuations and varying wall deposits is lower than with Cs-137. The half-life period of Co-60 is 5.27 years.
- *Cs-137* emits Gamma radiation with an energy of 0.66MeV. Typically, it is delivered as a point-shaped source, occasionally as a rod-shaped source. The half-life period of Cs-137 is about 30 years.

1.3 Measuring Principle

The principle of measurement is the irradiation method, utilizing the physical law of the absorption of radiation passing through matter. The resulting measuring effect is the ratio I/I_0 between the unattenuated radiation I_0 and the radiation I attenuated by the product being measured.

The mathematical correlation is as follows:

$$I = I_0 \times e^{-\mu \times \rho \times d}$$

The equation shows that with a given source and the respective mass attenuation coefficient μ the measuring effect is dependent only on the product density ρ and the measuring path d.

Since the measuring path is constant and possible product density changes at a certain measuring path due to exponential reasons do not have any effect any more, this measuring method is not affected by any chemical and virtually no physical properties of the product being measured. For this reason, the radiometric measuring principle ensures high reliability and low maintenance.

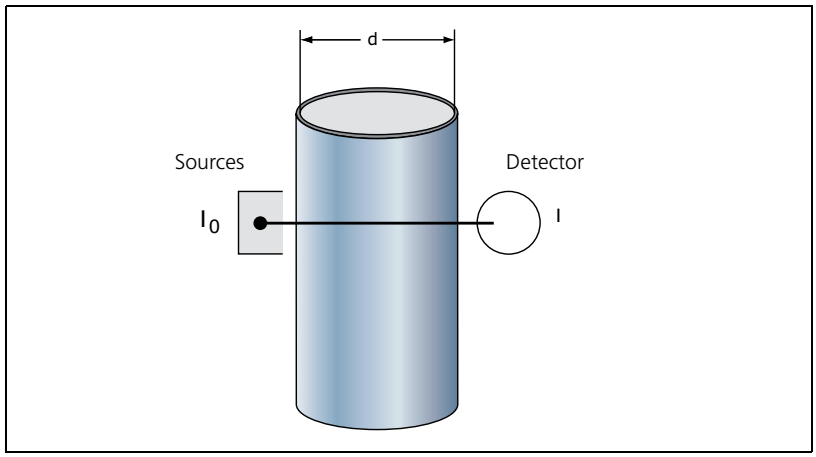


Fig. 1-4 Measuring Principle

1.4 Measuring Arrangements

The measuring arrangement for density, concentration and mass flow measurements usually comprises the following components:

- the radioactive source a)
- the shielding b)
- the SENSseries LB 480 c)
- the Pt100 resistance thermometer (optional) d)
- the mounting device e)
- the water cooling jacket for the detector (option)

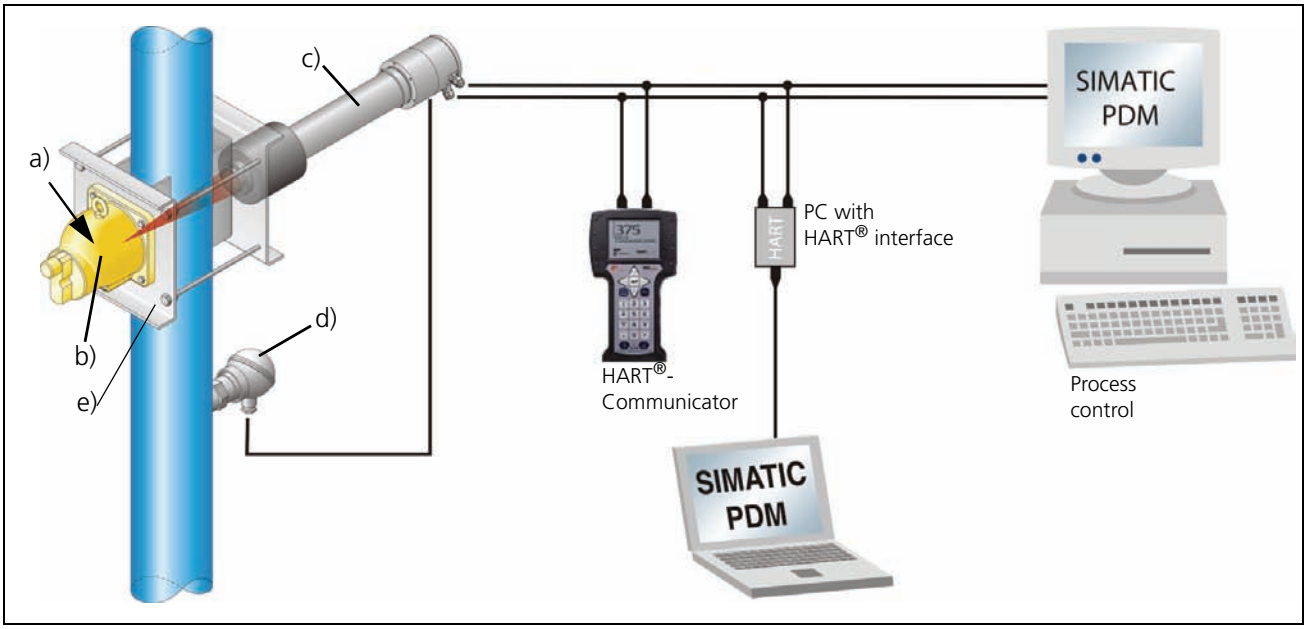


Fig. 1-5 Point source / Point detector arrangement

The supply voltage for the detector and the measurement signal from the detector to the evaluation unit are transmitted via the connecting cable between the detector and the evaluation unit.

Different arrangements and fixtures are required, depending on the measurement task and the characteristics of measuring product and containers. *Fig. 1-5* shows a schematic arrangement of a pipe with Pt100 resistance thermometer and a 90° mounting device for density, concentration, and mass flow measurement. 45° and 30° mounting devices are available to extend the measuring range. S- or U-shaped measuring sections can be used for smaller pipe diameters. A measurement in containers is also possible.

The respective selections are made during the planning stage and must be observed during assembly and commissioning.

1.5 Technical Data

If you are working under different operating conditions, please contact BERTHOLD TECHNOLOGIES.

Ambient temperature for "non-Ex" areas

	Operating temperature		Storage temperature
	uncooled	with water cooling	
CrystalSENS (Point detector)	-40 to +60 °C	to +100 °C	-40 to +60 °C
UniSENS (Rod detector) SuperSENS	-40 to +55 °C	to +100 °C	-40 to +55 °C

Ambient temperature in Ex-areas

Limited temperature ranges can apply for use in explosion hazardous areas.

Please note the maximum ambient temperature values for explosion protection in the Safety Manual.

General ambient conditions for explosion protection to CSA

Pollution Degree: 2
Installation Category: III
Altitude: up to 4000 m
Humidity: 90 % or less

The approvals listed on the type plate of the each detector are valid.

IP protection type

according to IEC 60529: IP66 and IP68
according to ISO 20653: IP69K
according to NEMA Standard Publ. 250: 4X and 6

Vibration, mechanical shock

Vibration: 1.9g
mechanical shock: 30g
according to DIN EN 60068-6 and 60068-2-27

EMC

Interference emission to EN 61326-1, Equipment Class A
Resistance to interference to EN 61326-1, NAMUR NE21 and EN 61326-3-1 (SIL)

Housing

Material stainless steel 1.4301/304; other stainless steels on request.

Weight

see *Volume 2*, *chapter 5*.

Water cooling

Stainless steel 1.4301/304; maximum 6 bar, hose connection R1/4" or 10 mm dia.

Current output

HART current output 4 ... 20 mA, floating

passive or active

Resolution better than 6µA

Impedance range active: 120 ohms to 500 ohms

Passive impedance range: up to 250 ohms at 12V, 500 ohms at 24V.

For safe HART® communication you need at least 250 ohms.

The maximum cable length of the HART® loop depends on the connected impedance as well as on the capacity and inductivity of the cable.

Max. cable length with BERTHOLD cable # 32024:

- 3300 m at 120 ohms
- 1600 m at 250 ohms
- 800 m at 500 ohms

The current output itself is monitored continuously and, in case of malfunction, signals 24 mA constantly via a redundant current path. The digital HART® communication remains in effect even on the redundant current path.

Power supply

Nominal voltages (depending on version):

100V to 240V_{AC} ±10%, 50/60Hz, max. 8VA or
24V_{DC} (18 to 32V_{DC}), max 8W

Cable conduits

4 cable conduits with M20 (ATEX) or ½" NPT (FM/CSA) for process connection, closed with dummy plugs. The screwed fittings which are not needed for the installation must be closed with sealing plugs that are suitable for the type of protection, see *page 2-166*.

Cable glands

Nickel-plated brass, 2 pieces for cable diameter 6 to 14 mm, TPE seal.

Optional: Cable glands made of stainless steel or EMC cable glands nickel-plated brass.

Cable cross-section

The cable cross-section is dependent on the cable glands used.

Wire cross-section for spring-type terminals

0.5 mm^2 to 2.5 mm^2; stripped length 10 mm

Scintillators

Type	Scintillator	Dose rate (typ)	Tempera-ture stabil-ity	Weight in kg	Weight in kg with water cool-ing
CrystalSENS (Point detector)	NaI (Tl) 50*50mm	0.5µSv/h for 300 cps	≤0.002%/°C	11 (w/o collim.) 20.5 (with col-lim.)	14.5 (w/o collim.) 24 (with collim.)
SuperSENS (Point detector)	Plastic scintillator 150*150mm	Cs-137: 0.14µSv/h for 1000cps Co-60: 0.2µSv/h for 1000 cps	≤0.01%/°C	60	61

High voltage generation

Voltage range of control 300V to 1300V
(error message below 300V and above 1300V)

Voltage range external setting 300V to 1300V

Sensitivity changes due to temperature variation or due to ageing are automatically compensated for by an automatic high voltage control.

Counter

Rate max. 1,000,000 cps

Automatic decay compensation

For Cs-137, Co-60 and a universally configurable isotope

Digital output

Open Collector; max. 100mA at 5 to 35V_{DC}; R_{max} 10kOhm; max. 2V voltage drop; at inductive load a freewheeling diode is required

The output can be used either for:

- Error signal
- Stop signal
- Max. alarm
- Min. alarm
- Detector temperature
- Interfering radiation

RS-485

For software updates

Detector temperature sensor

Two independent temperature sensors

Measurement deviation:
-25°C to 100°C: ±2K
-55°C to 125°C ±3K

Connection to PCS

Via current interface 4–20mA with optional HART® protocol according to Standard BELL-202 FSK.

1.6 Detector Codes

The detector codes are used for automatically adjusting the operating point of the high voltage and have already been set by the manufacturer. They only have to be checked or adapted when the electronics has been exchanged.

	Detector type	Scintillator size (in mm)	Detector code
CrystalSENS	LB 480-11	50x50 NaI	0[1]
SuperSENS	LB 480-31	150x150	23

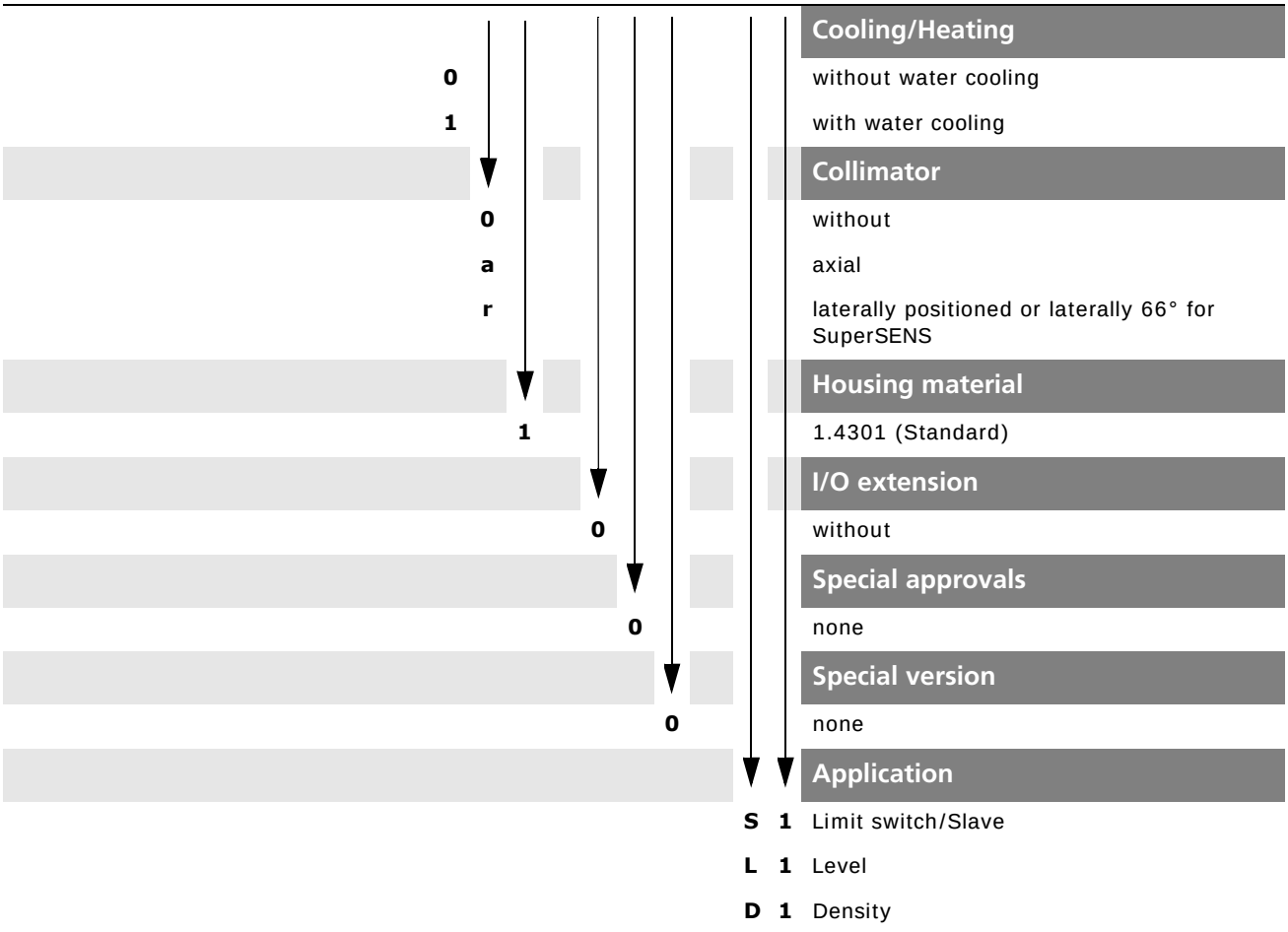
1 If the count rate is frequently or continuously under 200 cps (counts/sec), then you have to enter the detector code 1 instead of 0. With detector code 1, the detector is controlled even when the source does not supply any useful count rate. Low count rates of less than 200 cps will be obtained, for example, in a measuring arrangement as a minimum level switch (low-level alarm).

1.7 Nomenclature of the SENSseries LB 480

LB480 - 1 1 - 1A - 1 1 - 0 r 1 - 0 0 0 - L 1

	Scintillator
1 1	CrystalSENS 50 x 50 mm
2 1	UniSENS 500 mm
2 3	UniSENS 1000 mm
2 5	UniSENS 1500 mm
2 6	UniSENS 2000 mm
3 1	SuperSENS 150 x 150 mm
4 1	TowerSENS 1000 mm
4 2	TowerSENS 2000 mm
	Supply/Signal: Approval
00	without Ex-approval, passive, M20 socket
1A	ATEX Gas&Dust; Exe/Exe; passive or slave
2A	ATEX Gas&Dust; Exe/Exe; active
Z0	without Ex-approval, active, M20 socket
	Signal output
0	Slave detector
1	HART®
	Power supply
1	24 V_{DC}
2	100 V to 240 V_{AC}

LB480 - 1 1 - 1A - 1 1 - 0 r 1 - 0 0 0 - L 1



Cooling/Heating

0 without water cooling

1 with water cooling

Collimator

0 without

a axial

r laterally positioned or laterally 66° for SuperSENS

Housing material

1 1.4301 (Standard)

I/O extension

0 without

Special approvals

0 none

Special version

0 none

Application

S 1 Limit switch/Slave

L 1 Level

D 1 Density

2

Installation

Please pay attention to:

- the national safety and accident prevention regulations
- the national assembly and installation directions (for example, EN 60079)
- the generally accepted engineering rules
- the information on transport, assembly, operation, service, maintenance in this User's Manual
- the safety instructions and information in this User's Manual and the enclosed technical drawings and wiring diagrams
- the parameters, limit values and the information on operating and ambient conditions on the type labels and in the data sheets
- the labels on the device

⚠ CAUTION

Health hazards due to radiation!
Radiometric measurement devices use radioactive materials.

Danger due to radioactivity may occur if persons are exposed to radiation as a result of improper working with the measuring system.

Only persons who are trained in the handling of radioactive materials and possess the necessary know-how and skills are allowed to work with these measuring systems, see *Volume 1*, *chapter 3, "Qualification of the Personnel"*, *page 1-19*. Construction site personnel with experience in transporting heavy components may also be commissioned to carry out the installation. This construction site personnel, however, has to be guided by qualified persons; the Radiation Safety Officer has to be consulted for transportation and installation of the source.

Careful conformance to these regulations ensures that no hazard exists for persons using the devices.

Please be sure to comply with the Radiation Protection Guidelines applicable in your country and observe the Radiation Protection Instructions in *chapter 8, page 1-55*.

Storing the shieldings

The shielding with the radioactive source is delivered in a box in compliance with the regulations concerning the transportation of radioactive substances.

Risk of injury!

The weight of the source shielding may be up to several 100kg, depending on the version.

Make sure that the mechanical stability of the mounting devices matches the weight of the shielding and that the operating staff is wearing hard hats and safety shoes whenever doing any work on the shielding.

Take the shielding out of the box just prior to installation. Up to that time, store the shielding with the radioactive source in a location that is guarded against unauthorized access, see *chapter 2.1.4* on *page 2-98*.

Detector

Damaged cable glands must be replaced immediately. Under no circumstances should the detector be operated with damaged cable glands. If moisture has penetrated, you have to dry the terminal compartment.

Detectors which are used in hazardous areas must not be put into operation again following a mechanical shock or drop, as the explosion protection is no longer guaranteed. If this happens, the detector must be examined by a person authorized by BERTHOLD TECHNOLOGIES. If this is not possible, you have to replace the entire detector or return it to the manufacturer for inspection.

Corrosion resistance

The housing of the detector is made of stainless steel 1.4301 (304) and is therefore well protected from corrosion. The protection provided by stainless steels consists of a passive oxide layer on the surface, which is formed by oxidation with oxygen. However, if the surface gets damaged by unalloyed steel and particles of the unalloyed steel remain on the surface (ferrous contamination), then the surface may corrode at this contact point. Make sure, therefore, that neither during installation nor during operation other metal parts made of non-alloyed steel come into contact with the housing surface of the detector.

Mounting position

Size and position of the measuring range to be covered are determined in the projection phase for the measuring site and defined by drawings, sketches or details in writing. For assembly, these specifications have to be observed closely, since deviations may cause malfunctions of the measuring system.

Using the drawings of the shielding and taking into account the circumstances at the measuring site, carefully install the mounting brackets and fixtures.

2.1 Transport to the Installation Site

Risk of injury!

- Never step under hovering loads while unloading heavy system parts!
- Only use tested lifting equipment matching the transport weights.
- Maintain adequate safety margin.
- Wear hard hat and safety shoes.

Transportation may also be carried out by construction site personnel with experience in transporting heavy components. However, this construction site personnel has to be guided by authorized persons; the Radiation Safety Officer has to be consulted for transportation of the source.

2.1.1 Transporting Detector and Evaluation Unit

Risk of damage!

System parts may get damaged during transport.

Transport the detector and evaluation unit in the original packaging and protect the parts from vibrations.

2.1.2 Transporting Shielding with Source

Please observe the Radiation Protection Guidelines. Radioactive substances may be transported on public traffic routes only by persons in possession of the proper transport license!

Hazards due to nuclear radiation!

A source may be transported only in its shielding. The shielding must be closed during transportation and installation.

The shielding with the source inside can be lifted onto a palette by a fork-lift and transported to its destination. If the system parts are provided with eyebolts for transportation, they have to be used for lifting, unless the system parts are transported in their original packaging.

2.1.3 Temporary Storage of Sources

The operator has to take suitable provisions for temporary storage of sources at the place of installation between the period from source delivery to the start of the installation work.

Sources will be stored in their shieldings. A source may be stored only in a lockable room which is identified accordingly. Accessible controlled areas have to be identified and, if necessary, secured.

2.1.4 Installation Sites

⚠ WARNING

Risk of injury!

Heavy system parts may fall down if not installed properly.

The bearing capacity of the vessel walls or the brackets must be suitable for installation of the source with the shielding and the detector.

Free space must be foreseen at the installation site for:

- Freedom of motion for delivery of shielding, detector and evaluation unit.
- The electrical installation of the detector.
- Servicing and repair work, to install and dismantle parts.

The fixture for the assembled system components must not transfer any vibrations to the detector or the shielding. Likewise, it has to be ruled out that too high temperatures can be transferred to the system components.

The source with shielding and the detector are horizontally installed on the designated position on the outside of the vessel and outside a possibly installed heat insulation. The exact position for your system parts is stated on the calculation documents and the technical information prepared by BERTHOLD TECHNOLOGIES.

2.1.5 Unpacking and Cleaning System Parts

After unpacking, compare all parts with the packing list and check if the shipment is complete and shows any sign of damage. If necessary, you may have to clean parts.

If you detect any damage, notify the forwarder and the manufacturer immediately.

2.2 Detector Protection

NOTICE

Risk of damage!

The detector may be damaged due to strong mechanical stress, vibrations and high temperatures.

Prevent heat transfer from the detector holder to the detector by using a suitable heat-neutralizing suspension.

2.2.1 Cooling

The ambient temperature must not exceed the values specified in the technical data (see *Volume 2*, *chapter 1.5*, *page 2-89*). If temperatures exceeding 50°C are expected, you have to use a detector with water cooling jacket (see *page 2-109*). The cooling water cycle has to remain in operation even when the detector is turned off, if the maximum operating temperature is likely to be exceeded.

NOTICE

Risk of overheating!

A failure of the water cooling or insufficient flow can overheat and thus destroy the detector.

The maximum ambient temperatures are listed in the technical data in *chapter 1.5*, *page 2-89*. In addition:

- To prevent freezing, the water cooling system must be drained.
- Polluted cooling water may clog the water cooling system, which may result in the detector getting overheated and destroyed. It is therefore essential to use clean cooling water.
- The water pressure in the cooling jacket must not exceed 6 bar.

Water cooling in Ex-areas

The information in the Safety Manual regarding the ambient temperature for explosion protection also apply to the operation of a water cooling on detectors that are used in hazardous areas.

Detector temperature monitoring

The detector includes an internal temperature measurement which can be used to trigger a pre-alarm if higher temperatures are measured. The temperature switching point can be adjusted. The alarm can be picked up at the digital output (see *Volume 3, chapter 2.26*). If you operate the water cooling so that the temperature at the detector remains below 40°C, you could switch off the detector on exceeding a temperature limit of e.g. 50°C prematurely to protect the detector against overtemperature.

Cooling water curves

The required amount of cooling water is dependent on the possible heat transmission, the cooling water temperature and the detector type. You find the cooling water curves and further information in the technical specifications on *page 2-147*.

Connecting the water cooling

Water is always supplied from the bottom to prevent air pockets that can drastically reduce the cooling effect. Therefore, the detector has to be aligned so that the water exits at the highest point (see illustration on page *page 2-146*).

2.2.2 Sun Protection

If the detector is installed outdoors, it should be protected against exposure to direct sunlight by a weather protection roof.

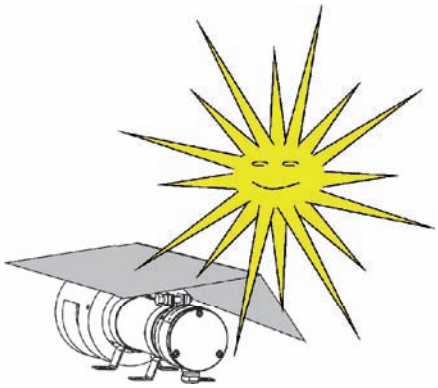


Fig. 2-1 Sun protection

2.2.3 Heavy-Duty Environments

When selecting the installation site, keep in mind that the detector should not be affected by mechanical stress or heavy vibrations, in order not to restrict its service life. If the measuring system is used in a heavy-duty environment, the detector and the shielding should be provided with an additional protective cover.

2.2.4 Precautions against Vibrations

Excessive vibrations or shocks on the detector shorten the service life. Mount the detector on a vibration-free support; you may also dampen possibly occurring vibrations or shocks using appropriate vibration absorbers.

2.2.5 Magnetic Fields

The detector is provided with an internal shielding that protects the photomultiplier against magnetic fields. Nevertheless, strong magnetic fields in close proximity to the detector may impair its function. In this case, the detector can be protected by an additional thick-walled steel tube, or the measuring point has to be relocated to another suitable position. In these cases BERTHOLD TECHNOLOGIES would be happy to help you.

2.2.6 Cleaning

Make sure not to damage the cable glands and the type plates by cleaning measures. The detector may be cleaned with water or gasoline. Remove coarse deposits with a wire brush. Grinding, filing or chipping away at deposits with the hammer is not permitted.

2.3 CrystalSENS (Point Detector)

Make sure that

– the detector or the source fixtures do not obstruct the beam path.

– there are no pipes, flanges, stirrers or other installations in the beam path.

Only installations that have already been taken into account in planning the measurement configuration are permitted. Otherwise, the curve is no longer linear; there may even be sections in the measurement range where the measured values do not change.

NOTICE

Function failure due to detector damage

The detector holder must not transfer any vibrations, shocks or heat on the detector, otherwise the detector is faulty or can fail completely.

Therefore, install the fixture on a vibration-free support or attenuate possible vibrations using vibration absorbers. Prevent heat transfer to the detector via the detector holder by using suitable insulating materials.

IMPORTANT

When installing the CrytsalSENS, please pay attention to the correct alignment relative to the source (see also page 2-103). The lateral opening (beam window) in the collimator releases the sensitive area of the detector and must be directed at the source.

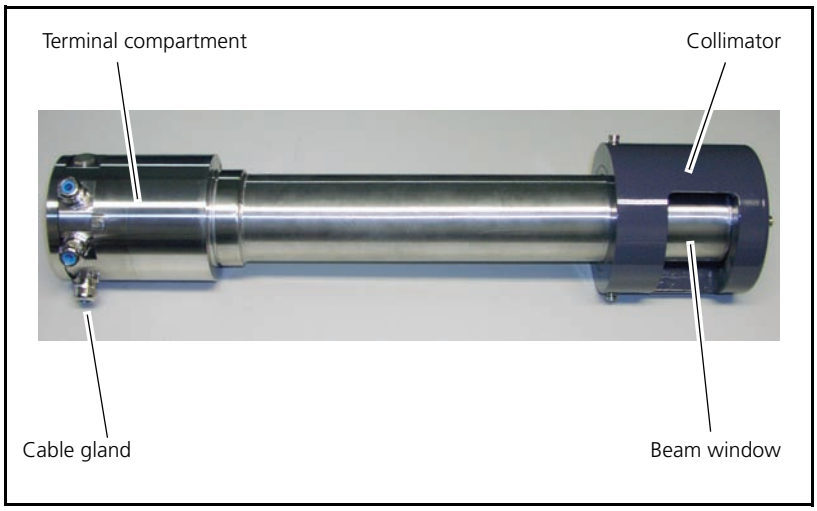


Fig. 2-2 CrystalSENS

2.3.1 Installation on Pipelines

Selection of the measurement site

When selecting the installation site, please keep in mind:

- Selection of measuring site: The pipeline must always be completely filled with the product being measured at the measuring site. If the pipeline is only partially filled, this may result in measurement errors.
- *Neither corrosion nor abrasion* or wall deposits must occur at the measuring site. This will result in incorrect measurements. That risk is lowest when the device is installed on vertical pipes.
- *Gas bubbles* in the product lead to measurement errors. The influence can be avoided or reduced by installing the measuring system at a location on the pipeline where the pressure is fairly high (installation in pressure pipes, at the foot of a standpipe). No gas bubbles must be present in the path of radiation.

  If no air bubbles are to be expected in the product, the *suction side of the pump* should preferably be used for installation to exclude air bubbles which might occur as a result of damaged pump seals.
- Measurements on *horizontal pipelines* should be performed using horizontal irradiation to reduce errors caused by deposit formation and gas bubbles. This will also help to avoid errors due to deposits or gas bubbles (see *Fig. 2-3*).

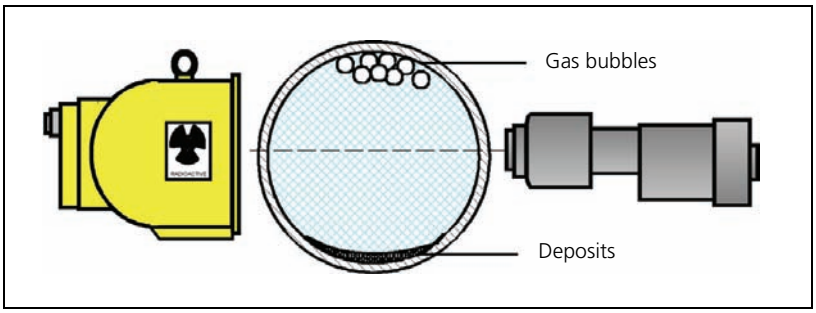


Fig. 2-3 Installation on a horizontal pipeline

- The pipeline should not be expanded. If it has to be done, it should be done only on vertical pipelines Pipelines may only be expanded at the measuring point if a continuous flow of the product over the entire pipeline cross-section will be ensured. Especially for products with high viscosity this is not always guaranteed; usually the product flows only in the center. Since the measurement covers the entire cross-section, it follows that the result will not be representative. In this case, the measurement result will not be representative.
- *Suspension measurements* must not be carried out directly at a pipe-bend, for there the material will not be distributed homogeneously. The distance from the bend must be the larger the higher the flow rate the bigger the difference between liquid density and solid density.

- On S or U-shaped measuring paths the shielding container with source has to be installed on top and the detector at the bottom (see Figure *2-4*).

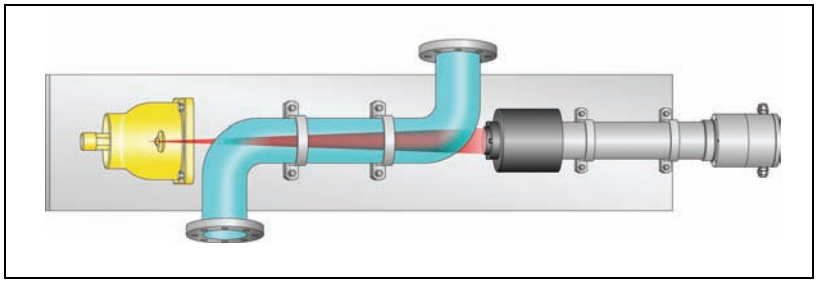


Fig. 2-4 Installation on S or U-shaped measuring path

- A thermal insulation consisting of glass or rock wool is unsuitable for installation, as it does not ensure safe installation of the measuring system. If, for technical reasons, thermal insulation at the measuring point is required, it must be made of a hard, non-hygroscopic material, i.e. aluminum silicate or it must not be installed directly on the pipeline, but on separate supports (see Figure *2-5*).

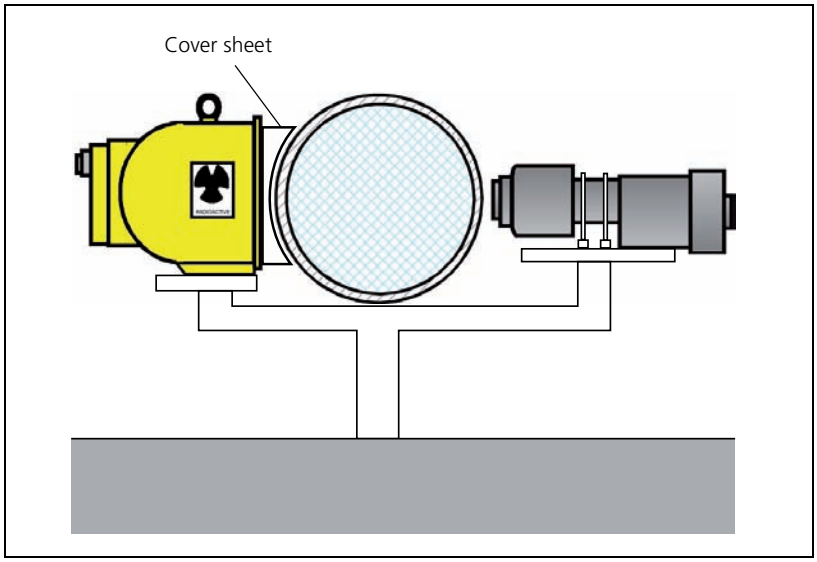


Fig. 2-5 External installation of shielding and detector

- According to the Radiation Protection Regulation areas where dose rates of > 3000 mSv/h (300 mrem/h) may be encountered are considered restricted areas. These areas must be protected by covers against unintentional reaching inside.
- The calibration of the measurement requires that samples of the product be taken. For this reason, a sampling point has to be provided near the measuring site.
- The product temperature for temperature compensation must be measured directly next to the density measurement.

2.3.2 Installation in a Container

The CrystalSENS is installed on the container using a fixture that is provided by the customer. The distance to the surface of the vessel or the surface of a thermal insulation should be about 100 mm. Clamps (see *page 2-107*) or an installation kit (see *page 2-107*) are used for installation of the detector on a bracket.

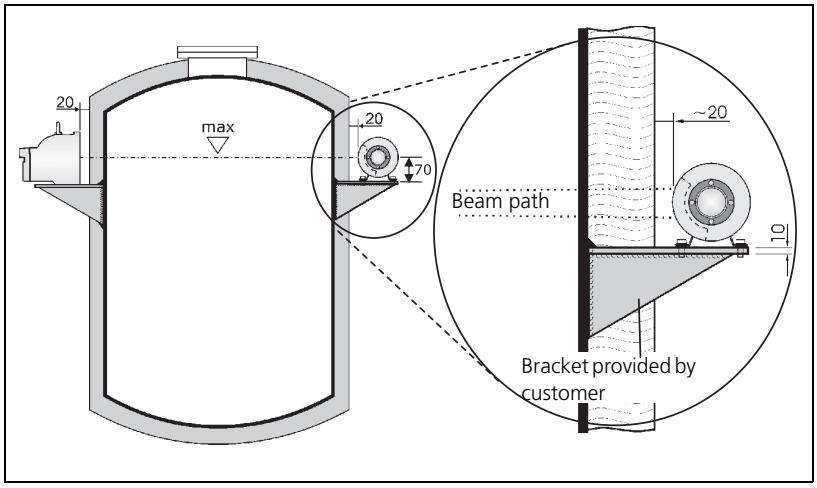


Fig. 2-6 Installing the CrystalSENS

If the bracket cannot be mounted on the container, then it has to be mounted on a support in the vicinity. *Fig. 2-7* shows three further alternative proposals (A, B, C) to mount the detector.

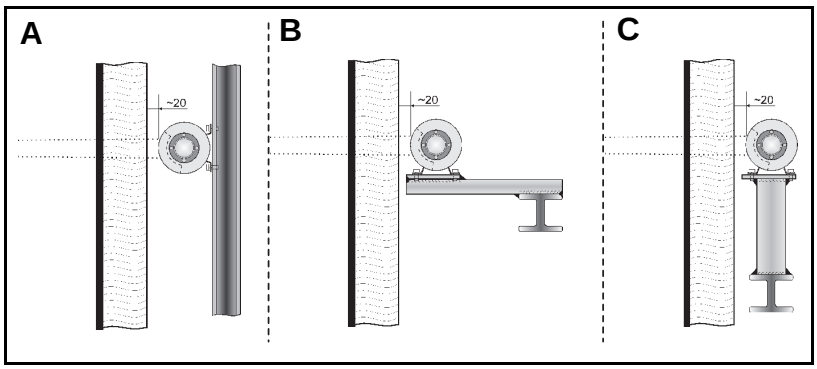
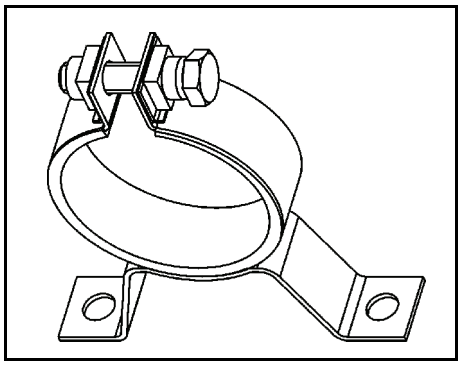


Fig. 2-7 Alternative installations

The technical drawings for CrystalSENS and its accessories can be found in chapter *"Technical Information"* on *page 2-166*.

Installation Procedure using Fastening Clamps

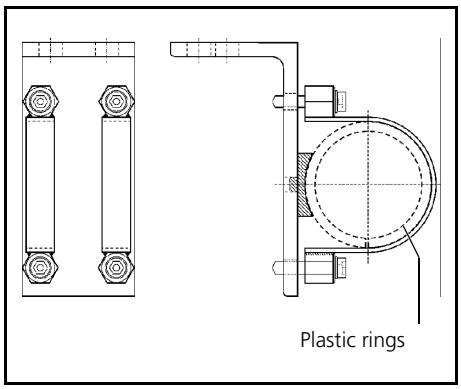


Stainless steel clamps are available for the installation of the detector.

Clamps for CrystalSENS without water cooling	Clamps for CrystalSENS with Water cooling
ID No. 31346 (1 set = 2 clamps)	ID No. 31347 (1 set = 2 clamps)

1. Make a suitable bracket for the container (*see "5 Technical Information"*).
2. Mount the bracket either directly on the container or on a stable support.
3. Mount the detector with the clamps on the bracket (see *chapter 5, "Technical Information"*).

Installation Procedure with Mounting Kit



A robust stainless steel holder is available instead of the clamps.

The holder consists of an angle on which two clamps are already mounted. You can bolt or weld the holder on a bracket.

For detectors without water cooling system you have to use the plastic rings shown with dashed lines in the drawing to the left for installation. They compensate for the difference in diameter between detectors with or without water cooling. Thus, the same bracket can be used for detectors with and without water cooling.

All metal parts of this holder are made of stainless steel. You find the technical drawing with dimensions in *chapter 5* on *page 2-139*.

Mounting Kit for CrystalSENS
ID No. 39246

1. Make a suitable bracket for the container (*see "5 Technical Information"*).
2. Mount the bracket either directly on the container or on a stable support.
3. Mount the holder with the detector on the bracket.

2.4 Installation of Pt100

A temperature measurement must be carried out such that the measured temperature is fairly equal to the product temperature at the density measuring site. The resistance thermometer must not lie in the path of radiation.

If the resistance thermometer cannot be installed in the pipeline or the container, it may also be installed on the surface. This type of installation requires that the pipeline including the resistance thermometer must be provided with temperature insulation over a length of 1 - 2 m, ensuring that the surface temperature of the pipeline at the temperature measuring point is fairly equal to the product temperature. In a container, the area around the thermometer must be provided with insulation. Nevertheless, it may happen, particularly with plastic or coated pipelines or containers, that very rapid temperature changes in the product to be measured will lead to temperature-induced measurement errors. Density changes are detected by the measurement without time delay; however, the necessary temperature correction is delayed due to the inertia of the temperature measurement. Operating the measuring system with a rather large time constant may reduce this effect.

2.5 Water Cooling

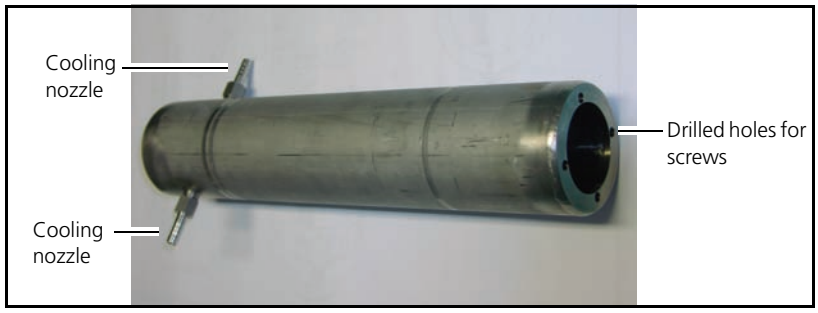


Fig. 2-8 Water cooling

If you have ordered the detector together with the water cooling, the water cooling is already mounted.

If you order the water cooling later, then you have to install it according to the following instructions.

Installing the water cooling

1. Remove the four front screws and pull the collimator from the detector.

NOTICE

To attach the collimator and the water cooling later to the detector again, you need four screws that are 5 mm longer than the original screws (not included).

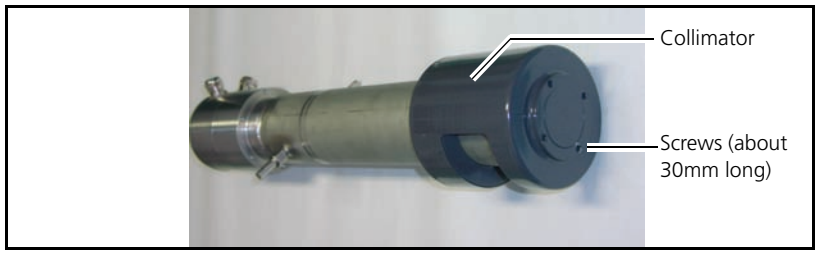


Fig. 2-9 Mounting screws for collimator

2. Slide the cooling jacket over the detector.

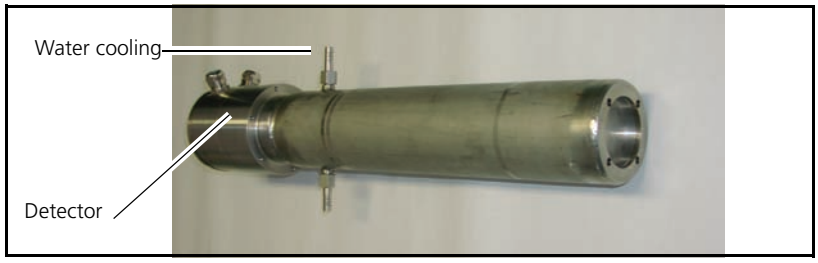


Fig. 2-10 Detector with water cooling

3. Remove the plastic ring from the collimator by opening the screws on the side of the collimator.

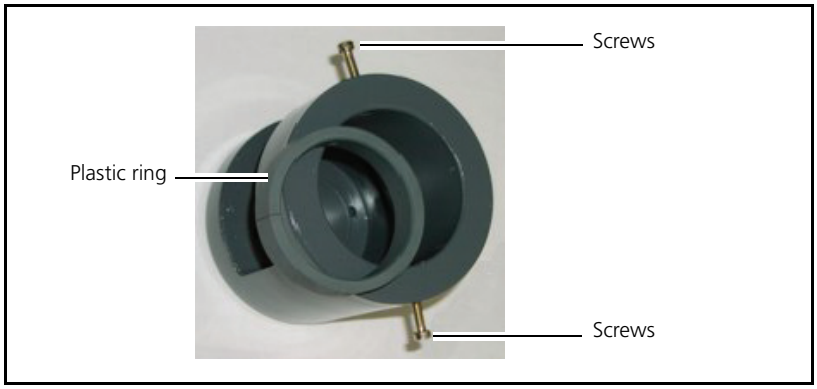


Fig. 2-11 Collimator for detector

4. Slide the collimator over the water cooling system, so that the beam window is facing the source. Position the collimator and water cooling relative to the pitch circle of the detector. Make sure that the position of the cooling nozzle is arranged so that later you have unhindered access to the installation of the water supply.

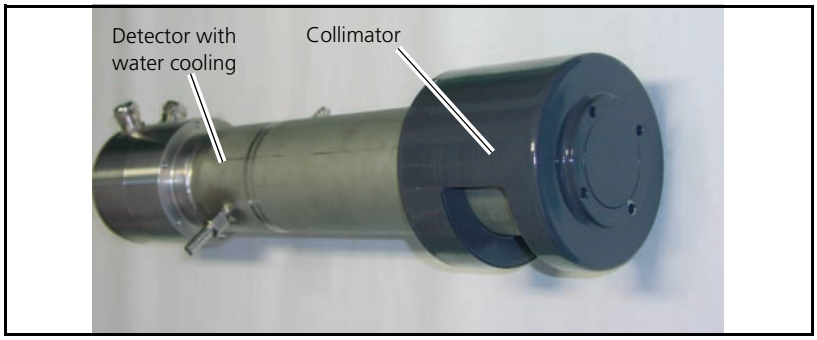


Fig. 2-12 Detector with water cooling and collimator

Please read the information on the water cooling on *page 2-100*.

2.6 Shielding

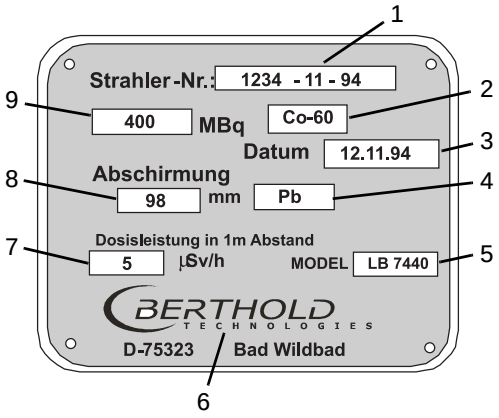
Shielding, source type, isotope and activity for each measurement configuration will be selected together with the customer to ensure compliance with the local dose rate limits. Co-60 or Cs-137 point sources are used which are tightly welded into a capsule made of titan or stainless steel. Therefore, no radioactive material can escape, provided the source is intact, and contaminations are ruled out.

For point source shieldings, the capsule with the source is fixed on a source holder and installed in the shielding. For rod source shieldings, a rod source is placed into the existing borehole of the shielding. The shielding matches the length of the source.

The distance from the source shieldings to the vessel surface is designed such that reaching into the beam channel with the hand is prevented (reference value approx. 20 mm). For shieldings with a rotary cylinder (vertically standing cylinder) make sure that the cylinder can be rotated on the vessel surface without friction.

Apart from a few exceptions, all shieldings are filled with lead to keep the dose rate on the surface with small construction sizes as low as possible. Therefore, the shieldings are quite heavy. The weights are listed in the technical drawings in *chapter 5* on *page 2-139*.

For information on the design of source and shielding please refer to the technical documentation and the type plate (*Fig. 2-13*).



1 Source number
2 Isotope
3 Source manufacturing date
4 Shielding material
5 Type of shielding
6 Manufacturer of the shielding
7 Dose rate in 1m distance
8 Effective shielding thickness
9 Activity

Fig. 2-13 Type plate

Please observe the safety instructions in *Volume 1* on *page 1-55*. A source may be transported only in its shielding. Keep the source shielding closed during storage, transportation and installation.

The arrangement of the sources is defined during the planning stage and entered in a drawing or defined in writing. These details must be observed carefully to ensure correct linearization data. Detailed information about the design and function of each shielding being used can also be found in the drawings, which are included in the documentation.

2.6.1 Point Source Shielding LB744X

The radiation warning sign identifies the start of the controlled area, provided the controlled area is *outside* the shielding. If the controlled area is *inside* the shielding, then the radiation warning sign attached on the shielding suffices.

Fig. 2-14 Radiation warning sign

⚠ CAUTION

Increased radiation dose due to open beam channel!

A too high dose of radiation may be harmful to your health.

A source may be transported only in its shielding. The shielding must be closed during transportation and installation.

The radiation exit is cone shaped with an angle of about 10°. During installation, the shielding and thus the useful beam must be aligned such that they point exactly towards the detector.

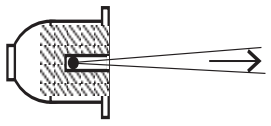


Fig. 2-15 Point source shielding

The shielding consists of a lead cylinder with source exit channel (7), surrounded by a steel jacket (*Fig. 2-16*). The locking core (6) is firmly connected with a lever (4). The "OPEN" and "CLOSED" positions are secured and the removal of the sources by unauthorized persons is prevented by a padlock (3).

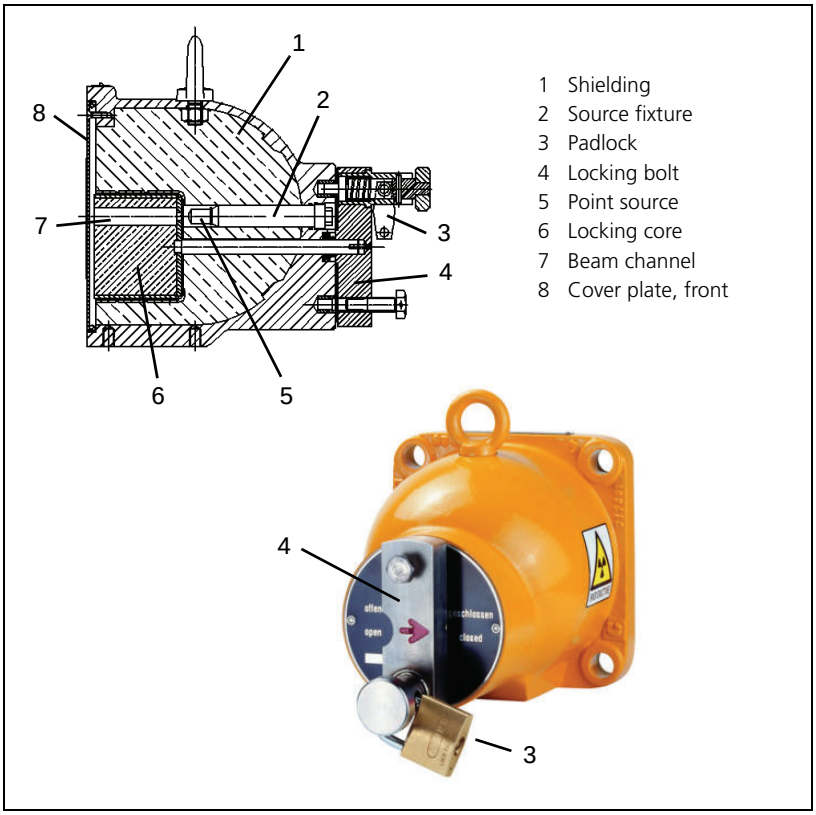


Fig. 2-16 Cross-section drawing and photo of the point source shielding, top: beam channel open, bottom: beam channel closed

Turning the lever (4) will also rotate the locking core and open the source exit channel towards the detector. The arrow on the lever is pointing to "OPEN".

The source exit channel must be closed during transportation, during installation and while carrying out work on the vessel. The arrow on the lever is pointing to "CLOSED". In the "OPEN" and "CLOSED" position, the lever or the locking core are protected by a padlock.

NOTICE

Function failure due to damage

The detector fixture must not transfer any vibrations or heat onto the shielding; otherwise the locking mechanism may be damaged and the shielding effectiveness may be adversely affected.

Therefore, install the fixture on a vibration-free support or attenuate possible vibrations using vibration absorbers. Prevent heat transfer by using suitable insulating materials.

Installing the shielding

The shielding can either be installed on a bracket or on a flange. Size and position of the measuring range to be covered are determined in the projection phase for the measuring site and defined by drawings, sketches or details in writing. For assembly, these specifications have to be observed closely, since deviations may cause malfunctions of the measuring system.

The mounting flange or mounting bracket for the shielding must take into account the angle foreseen when preparing the installation. Mounting parts such as adjustable angles allow adjustments or modifications later within certain limits.

3

Electrical Installation

Installation should only be performed by a qualified electrician (competent person).

The safe operation of the detector is only guaranteed you if follow the safety instructions described in *Volume 1*, *chapter 6*.

3.1 Cable Entries

Depending on the model, the detectors are provided either with M20 (ATEX) or with ½" NPT cable entries (FM/CSA), through which the electrical cables are be installed according to regulations. Conduits or cable glands can be screwed into the cable entries. They have to be licensed for the respective type of protection and have to be installed carefully in accordance with regulations! Cables and cable conduits have to be aligned such that water cannot flow into the bushing along the cable. Also make sure that all cables that are installed are not subject to abrasion, strain or kinks.

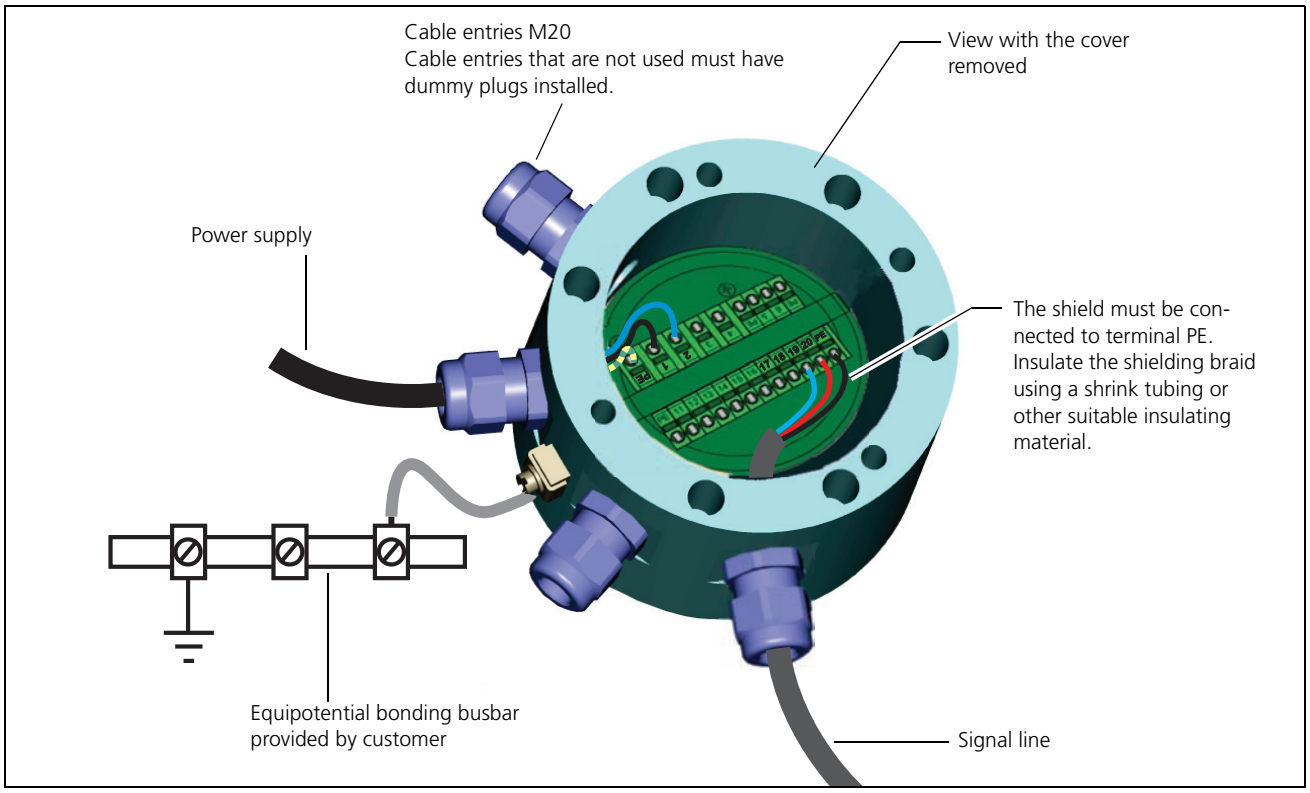

Cable entries M20
Cable entries that are not used must have dummy plugs installed.
View with the cover removed
Power supply
The shield must be connected to terminal PE. Insulate the shielding braid using a shrink tubing or other suitable insulating material.
Equipotential bonding busbar provided by customer
Signal line

Fig. 3-1 Detector housing open - top view

Cable entries that are not used must have dummy plugs installed.

3.1.1 Multi-detector Operation

Refer to the connection diagram for the multi-detector operation in the Technical Information on *page 2-139*.

3.1.2 ATEX Connection Type

Follow the safety instructions in *chapter 5, "Explosion Protection"*, *Volume 1*.

3.1.3 FM/CSA Connection Type

A stopping box (conduit seal) has to be installed on each cable entry used directly behind the detector housing.

3.1.4 Replacing a Detector or Using it at another Measuring Point

Detectors which are used in non-hazardous areas are not subject to the supervision and maintenance of Ex-protection experts; therefore, it is not guaranteed that, for example, for repair or assembly, the necessary care is taken which is required for the detectors in Ex-areas. The Ex-protection safety is therefore no longer guaranteed. The same applies to the intrinsic safety of detectors. Therefore:

- Detectors that are used in the non-Ex area may not be used in an Ex area.
- Intrinsically safe detectors, whose intrinsically safe signals are connected to non-intrinsically safe circuits must not be connected to intrinsically safe circuits any more.

3.2 Terminals

3.2.1 Master Terminal Compartment

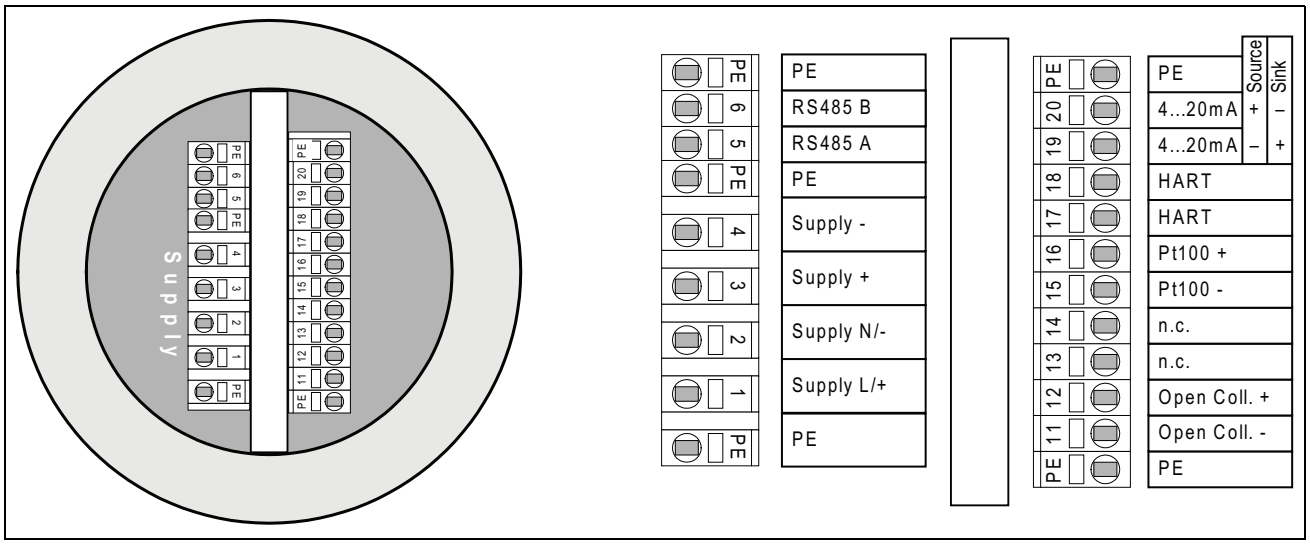


Fig. 3-2 Master Terminal Compartment

Permissible conductor cross-section for terminals:

- with ferrules 0.5 - 1.5 mm² (AWG 21 - 16 flexible)
- without ferrule 0.5 - 2.5 mm²
  (AWG 21 - 14 flexible or solid)

Terminal description

Terminals	Master
	HART®
PE (5 x)	Ground connection and screen
1 - 2	Power supply: 100V to 240V_{AC} or 24V_{DC}, depending on version
3 - 4	Like terminals 1 - 2: additional terminal pair for transmission (loop through) the supply voltage to the next slave (only permitted for supply of 24 V_{DC})
5 - 6	RS-485: for multi-detector operation, connection for slave detector, service interface and software update
11 - 12	Open collector signal output with reverse voltage protection ALARM: no power NORMAL: Current flows The supply voltage for the open collector must be between 5 and 36V. The maximum current that may flow through the open collector is 100mA. Depending on the supply voltage, this leads to the following resistance values which must be connected: 5V: ≥30Ω 12V: ≥100Ω 24V: ≥220Ω 36V: ≥340Ω If the resistance value is not reached, the open collector may be damaged.
13 - 14	Reserved for optional I/Os
15 - 16	Pt100 for temperature compensation in density measurement
17 - 18	Like terminal 19 - 20: additional terminal pair for parallel connection of a HART® Communicator

Terminals	Master
	HART®
19 - 20	HART® current output: 4-20 mA current output for measured value output and parameterization. This current output is used for the continuous transfer of the measured value and for display of the error status via the adjustable fault current: – 4–20 mA for current measured value. – Adjustable fault current from 3.5 to 24 mA in case of error. The current output is continuously monitored and in case of failure signals the fault current set via the software through a redundant current path. The digital HART® communication remains in effect even on the redundant current path. – Max. cable length with BERTHOLD cable # 32024: – 1600 m at 250Ω – 800 m at 500Ω – Depending on the type, the current output is operated in the Sink or Source mode. Source mode (active current output) – Impedance range: 250 ... 500Ω Sink mode (passive current output) – Supply voltage: 18 ... 32V_{DC} max. impedance: 500Ω

Signal cable with shielding

We recommend using a screened cable for the signal lines. The screen has to be connected to the detector on the PE terminal in the terminal compartment of the detector, or better, to suitable EMC cable glands.

3.3 Connecting the Detector

If lines are already connected to the detector, keep in mind:

Explosion hazard!

As long as the detector is supplied with power, do not open the terminal compartment cover if there is a potentially explosive atmosphere.

Risk of fatal injury due to electric shock!

If the terminal compartment cover is open, you are at risk of getting an electric shock when you touch the terminals. Do not connect or disconnect any wires as long as the device is supplied with line voltage.

Depending on the type of detector, the detector is supplied with 110/230 V_{AC} or 24 V_{DC}. With the version with 110/230 V_{AC} and with the line voltage switched, please pay attention to adequate protection against accidental contact.

Always follow the safety instructions for "Electrical Installation" on *page 2-115* and if applicable for *"Explosion Protection"* on *page 1-23*.

IMPORTANT

Open the terminal compartment only in dry ambient conditions, never in the rain.
Moisture in the terminal compartment can both cause a short circuit with other lines or cancel the explosion protection.

Hereinafter, it is assumed that no cables have been connected yet. Otherwise, make sure that the detector is not live.

As the intensity of electromagnetic interference on the cables is very different in the systems, we recommend using a shielded cable. Signal cables must not be laid parallel to power lines. This is especially important for master lines and lines with high current load: Keep a minimum distance of 50 cm.

Cable shields can be placed on the terminals marked with PE. If EMC cable glands are used, the shield must be placed directly in the cable gland. Screened cables must be connected at one end to the detector. Even with a multi-detector application, put on the shield of the RS-485 connection cable on one side only.

For the following activities, use the checklists in *chapter 5.5.1* on *page 1-36* and *chapter5.5.2* on *page 1-38* to document the accuracy and completeness of your work.

For detectors that are used in hazardous areas, the detector housing (*Fig. 3-3*) and thus the pressure-proof enclosure of the electronics may be opened only by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES.

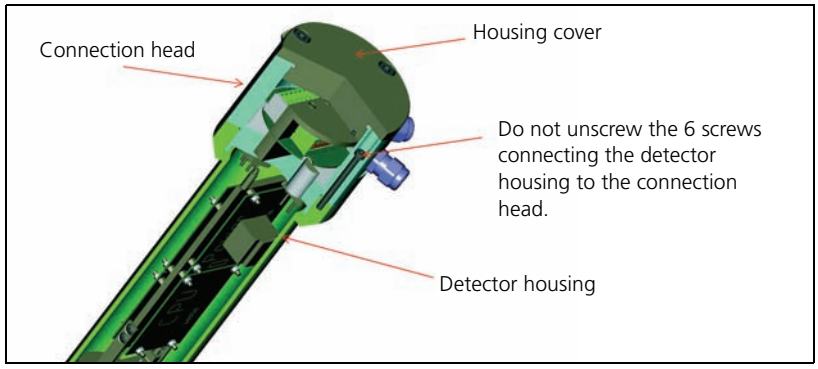

Connection head
Housing cover
Do not unscrew the 6 screws connecting the detector housing to the connection head.
Detector housing

Fig. 3-3 Detector housing with connection head

Connecting cables

- ▶ Unscrew the housing cover (M5 and M8 Allen wrench).
- ▶ Remove the sealing plug on the bushings that you need for your cable entry.
- ▶ Install the screwed cable gland or for FM/CSA a conduit system with a conduit seal before the cable entry into the terminal compartment.

IMPORTANT

In Ex-protected areas, use only cable glands that are approved for your explosion protection.

- ▶ Pull the connection cables with the complete external insulation through the cable entry into the terminal compartment.

  Make sure that the cable diameter of the cable used is suitable for the screw connection.
- ▶ Make sure when installing the cables that mechanical damage to the conductor insulation from sharp edges or moving metal parts will be ruled out.
- ▶ Keep the cable length long enough to create a cable loop for strain relief before the housing inlet.

- Install the connecting cables in the terminal strip so that
  - dirt and moisture is avoided in the terminal compartment;
  - the wires are not damaged when stripping;
  - the conductor insulation extends into the terminals when stripping;
  - the minimum bending radii permitted for the respective conductor cross-section are not fallen below.
- Stranded leads have to be stripped 10 mm, and may be introduced only when the spring-type terminal was opened by a suitable tool (screwdriver with a blade width of about 3 mm). Make sure that all wires of the stranded lead are completely trapped and no small wires project from the terminal. The insulation of the wire must extend into the terminal insertion opening.
- Connect the wires according to the wiring diagram in *chapter 3.1* and *3.2* to the terminal strip of the detector. Use at least the following terminals:
  - Signal output: Terminals 19 and 20
  - Power supply: Terminals 2 and 3 and the PE terminal for the grounding conductor connection.
- Place the cable shields on the terminals marked with PE. Place the cable shield directly inside the screw fitting, if you are using EMC screw fittings.
- Make sure that the wires sit securely in the terminals.
- Connect the terminal for potential equalization to the outside of the detector housing using the equipotential busbar.
- With cable glands: Tighten the hexagon nuts of the cable entries so much that the tightness of the terminal compartment and the strain relief protection of the connection points are secured. The tightening torques can be found on *page 1-34*.
- Remove any loose metal particles, dirt and traces of moisture from the terminal compartment.
- Only with Ex-protection FM/CSA: When installing pipework in a hazardous area, encapsulate the conduit seal using a suitable filler.
- Make sure that the cover seal is undamaged and the snap rings are placed on all the cover screws.
- Close the housing carefully with the cover seal and the housing cover. To do this, put the housing cover with the sealing on the housing and tighten the Allen screws using the specified torque: depending on the version, M5 with 4 Nm or M8 with 17 Nm (standard values).

- ▶ Create cable loops with the connected lines in front of the housing entrance and provide for an appropriate strain relief of the connected cables. If there is a danger that the cable may be used as a stepladder, then the cables must be installed protected, for example in conduits.
- ▶ Now you may turn on the line voltage.

After completing work, use the *"Plan for Inspection of the Terminal Compartment"* on *page 1-38*.

4

Repair, Maintenance and Upkeep

IMPORTANT

Spare parts for detectors used in the Ex-area must be mounted solely by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES. If this is not possible, you must replace the entire detector or return it to the manufacturer for repair.

For devices that are *NOT* used in an Ex-area, the following parts may be replaced at your own risk and taking into account a loss of any existing warranty by BERTHOLD TECHNOLOGIES:

– the complete detector electronics
– the complete connection head
– the crystal at the CrystalSENS
– the multiplier (PMT)
– the multiplier crystal combination
– the detector housing

BERTHOLD TECHNOLOGIES recommends to have detectors repaired solely by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES.

Only original spare parts by BERTHOLD TECHNOLOGIES may be used.

Please follow the instructions in the Safety Manual (*Volume 1*) for every repair and the instructions in *chapter 3, "Electrical Installation"*, *page 2-115*.

After every repair, maintenance or upkeep, please use the checklists on *page 1-36* and *page 1-38*.

4.1 Safety Instructions

Observe the legal provisions that apply in your country!

Repair and maintenance work on the detectors must be performed by competent personnel, see *Volume 1*, *chapter 3, "Qualification of the Personnel"*, *page 1-19*. If in doubt, return the entire detector for repair to BERTHOLD TECHNOLOGIES.

Also note the following points:

- Repairs to electronic circuits on the board of your SENSseries detector must be carried out exclusively by the manufacturer.
- Any time you are working on electrical components, you have to observe the relevant safety regulations. Please refer to the safety instructions at the beginning of this User's Manual. Turn off the detector and disconnect any relay contacts and all inputs and outputs.

Danger due to radiation!
Radiometric measurement devices use radioactive materials.

The source emits radiation through the source exit channel. There may be a danger arising from radioactivity when people are exposed to this radiation.

Always keep the source exit channel of the shielding closed during assembly work.

Any work in the direct vicinity of the shieldings containing the radioactive source may be performed only following proper training and under professional guidance, see *Volume 1*, *chapter 3, "Qualification of the Personnel"*. Repairs performed by untrained persons may result in the loss of explosion protection.

Corrosion protection

If non-alloyed steel comes into contact with a stainless steel surface, the surface can corrode at this point. Make sure, therefore, that neither during installation nor during operation other metal parts made of non-alloyed steel come into contact with the housing surface of the detector.

ESD protective measures

The electronics of this measuring system contains electrostatic highly sensitive components. We recommend that you wear an ESD wrist strap during installation or repair work. Connect this wrist strap to the ground conductor.

4.2 Replacing the Complete Detector

Reuse of detectors

Detectors that are used in the non-Ex area may not be used in an Ex area.

Intrinsically safe detectors, whose the intrinsically safe signals are connected to non-intrinsically safe circuits must not be connected to intrinsically safe circuits any more.

Explanation:

Detectors which are used in non-hazardous areas are not subject to the supervision and maintenance of Ex-protection experts; therefore, it is not guaranteed that, for example, for repair or assembly, the necessary care is taken which is required for the detectors in Ex-areas. The Ex-protection safety is therefore no longer guaranteed. The same applies to the intrinsic safety of detectors.

Replacing the detector

Proceed as follows to replace the detector:

- ▶ Write down all software parameters of the installed detector.
- ▶ Disconnect the detector from power.
- ▶ Turn off any peripherals connected and all inputs and outputs.
- ▶ Unscrew the housing cover (M5 and M8 Allen wrench).
- ▶ Open wiring on digital board and on the terminals.

Tip

If the wires are not marked, we recommend marking the individual wires before disconnecting them.

NOTICE

After you have disconnected the wires and cables, reattach the housing cover with sealing immediately, so that the parts cannot be damaged during the mechanical removal.

- ▶ Dismantle the old detector from the fixture.
- ▶ Mount the new detector onto the fixture.
- ▶ Unscrew housing cover of the old detector.
- ▶ Connect the wires.
- ▶ Close the housing carefully with the housing cover. To do this, put the housing cover with the sealing on the housing and tighten the Allen screws using the specified torque: depending on the version, M5 with 4 Nm or M8 with 17 Nm (standard values).
- ▶ Turn on power.

- Enter the previously documented parameters of the detector *with the exception of the parameter HV-Default* via the HART® Communicator or an alternative user interface.
- Perform a new calibration (see *Volume 3, chapter 5*).

Now the detector is ready for operation again.

4.3 Replacing the Electronics Module

Explosion hazard!

For detectors used in the Ex-area, the electronics module must be replaced solely by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES. If this is not possible, you must replace the entire detector or return it to the manufacturer for repair.

IMPORTANT
Removal and installation of parts of the SENSseries detector should be carried out in a clean workshop environment.

The electronics module has to be dismantled if one of the following parts has to be exchanged:

- Electronics module (see *page 2-129*)
- Crystal-multiplier combination for CrystalSENS (see *page 2-132*)

The electronics in the CrystalSENS is dismantled together with the crystal-multiplier assembly. In the SuperSENS the electronics is dismantled together with the multiplier.

4.3.1 Dismantling the Electronics Module

IMPORTANT
Since all detector parameters are stored on the electronics module, you have to enter all the parameters again after you have exchanged the electronics. If you still have access to the detector parameters before the exchange, write them down so you can then enter them into the new electronics. Otherwise, you have to re-configure and re-calibrate the detector again. Please see the appropriate volume for instructions.

To replace the electronics module, you have to dismantle the housing overtube from the connection head.

You may carry out the activities described below only if the detector is not used in an Ex-area.

▶ Write down all software parameters of the installed detector.

▶ Disconnect the detector from the power and switch off the detector and any connected peripherals.

⚠ WARNING

Risk of fatal injury due to electric shock!

If the housing is open you may come into contact with live parts if the power supply is connected.

Make sure when you open the cover that no supply voltage is applied to the terminals. Use a voltmeter.

- ▶ Unscrew the housing cover (M5 and M8 Allen wrench).
- ▶ Unscrew the six screws that connect the detector housing to the connection head (Torx T25).

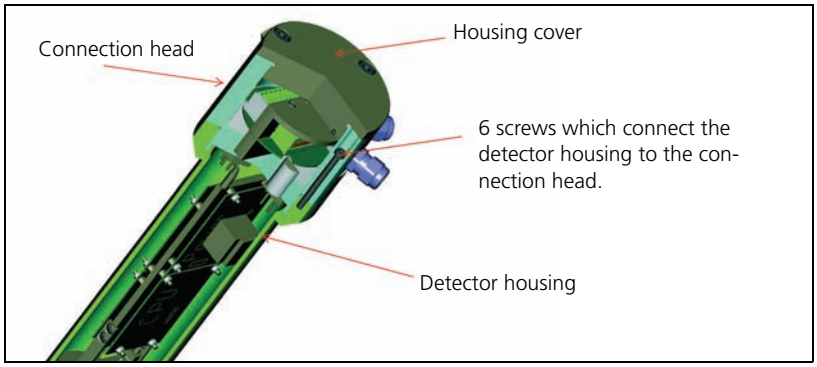


Fig. 4-1 Dismantling the detector electronics

- ▶ Carefully pull out the electronics module together with the crystal-multiplier assembly.
- ▶ Remove the overtube with the multiplier (SuperSENS) or the crystal-multiplier assembly (CrystalSENS) from the electronics.
- ▶ Loosen the connecting wires between connection head and electronics.
- ▶ Remove the electronics from the connection head by opening the four stud screws on the side of the metal plate of the PCB holder.
- ▶ Now you can replace the entire electronics module.

4.3.2 Installing the Electronics Module

Reassemble the electronics module in reverse order.

- Connect the wires between connection head and electronics correctly.
- Check that the wires sit firmly in the terminals.
- Replace the O-ring that seals the housing.
- Make sure that neither moisture nor metal chips are present in the connection box.
- Carefully insert electronics module with the crystal-multiplier assembly again into the housing.
- Attach the connection head to the detector housing again. Tighten screws evenly and alternating between screws.
- Close the housing carefully with the housing cover. To do this, put the housing cover with the sealing on the housing and tighten the Allen screws using the specified torque: depending on the version, M5 with 4 Nm or M8 with 17 Nm (standard values).

If you have installed a new electronics module:

- Place the supplied sticker over the number of the Dev. ID on the type plate.
- Turn on the power supply of the detector again.
- Set the software parameters again using the list you have noted down at the beginning. See also *Volume 3* on *page 3-175*.

  Separate User's Manuals are available for user interfaces such as SIMATIC PDM or FOUNDATION™ Fieldbus.

This completes the replacement of the electronics module.

4.4 Replacing the Crystal-Multiplier Assembly (for CrystalSENS)

Explosion hazard!

For detectors used in the Ex-area, the crystal-multiplier assembly must be replaced solely by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES. If this is not possible, you must replace the entire detector or return it to the manufacturer for repair.

Replacing the crystal-multiplier assembly can cause a change in sensitivity of the detector for gamma radiation. Therefore, check the calibration after the replacement and possibly perform a new calibration.

You may carry out the activities described below only if the detector is not used in an Ex-area.

- ▶ Remove the electronics module as described on *page 2-129*.
- ▶ Dismantle the crystal: loosen and remove the sleeve nut on top of the overtube of the multiplier tube (PMT). Then pull the crystal off the multiplier.
- ▶ Remove the PMT overtube from the PCB holder.
- ▶ Pull the multiplier from the base of the electronics.
- ▶ Plug the new multiplier into the socket. Please observe the encoding nose.
- ▶ Install the electronics module into the detector as described on *page 2-131*.

IMPORTANT
The replacement of the multiplier requires a readjustment of detector code and HV parameters. Please read also Volume 2, chapter 1.6, "Detector Codes", page 2-92, and Volume 3, chapter 2.39, "Plateau Measurement", page 3-234.

- ▶ Check the function of the measurement. If you detect any deviations, carry out a new calibration, see *Volume 3*, *chapter 5*, on *page 3-253*.

  Separate User's Manuals are available for user interfaces such as SIMATIC PDM or FOUNDATION™ Fieldbus.

This completes the exchange of the crystal-multiplier assembly.

4.5 Checking the Detector

Scintillation counters do not include any wearing parts and their service life is not limited, provided they are used under normal operating conditions. Malfunctions or aging in the scintillation detector can only be caused by excessive mechanical or thermal stress.

Scintillation counters are used as detectors, since only these detector systems provide the required high sensitivity to Gamma radiation and their service life is independent of the intensity of the radiation field.

The number of light flashes per time unit is a measure of the intensity of the radiation field. The individual flashes of light are very short, so that a high resolution is obtained; this detector can be employed for high count rates.

The flashes of light are converted into electrical signals in a *photomultiplier* (PMT), which is optically coupled to the detector.

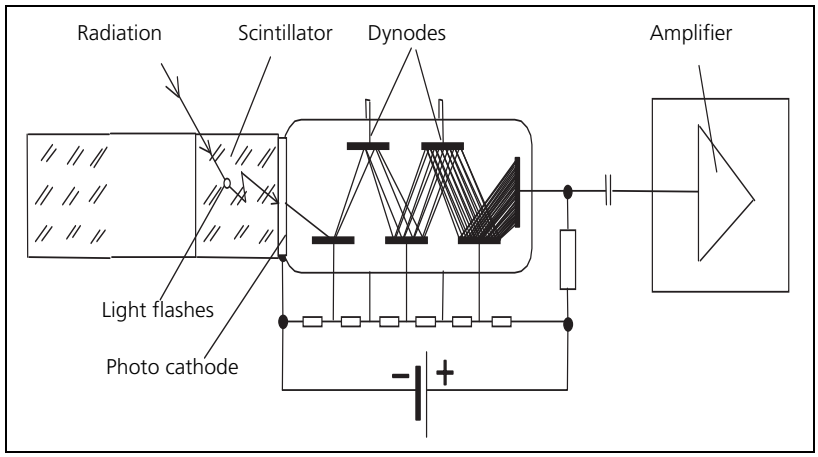


Fig. 4-2 Scintillation detector

The *point detector* CrystalSENS uses a 50/50 NaI crystal as a scintillator, the SuperSENS detector uses a 150/150 scintillator.

4.5.1 Checking the NaI Point Detector (CrystalSENS)

Malfunctions of the scintillation counter are not always indicated by a missing pulse rate; it is also possible that the specific Gamma sensitivity appears to have changed or obvious instabilities are apparent. These errors can be detected only by means of a plateau check. The detectors of the SENSseries include a function for automatic plateau recording. The check can be performed using the source at the measuring site or better a test source. Plot the measurement results in a curve (*Fig. 4-3*). The detector works perfect when you get a clearly visible plateau; the position of the plateau within the high voltage range does not matter. The plateau is recorded automatically. See also *page 3-283*.

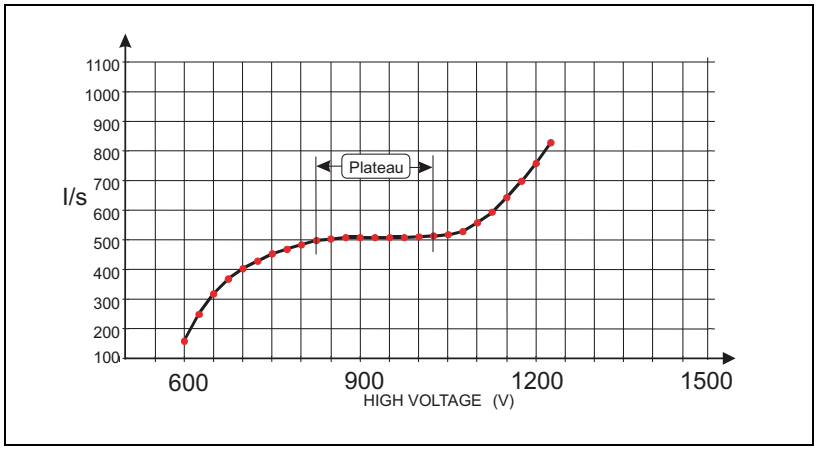


Fig. 4-3 Plateau curve of NaI detector

If the count rate changes by more than 5% per 100 V high voltage, or if the plateau is shorter than 50V, the scintillation counter will be unstable. In this case the complete detector or the crystal-multiplier assembly should be replaced.

IMPORTANT

The radiation conditions must be constant while recording the plateau!

4.5.2 Checking the Crystal-Multiplier Assembly

The plateau becoming too small or too steep indicates faults in the crystal-multiplier assembly. They can often be detected through visual inspection. To do this, take the crystal-multiplier assembly apart. To separate both parts, remove the Mu metal shielding and carefully detach the crystal from the multiplier window by gently sliding the crystal sideways. Wipe silicon oil traces off the mating faces of crystal and multiplier using a soft cloth. While you are doing this, make sure that the multiplier is not exposed to bright sunlight.

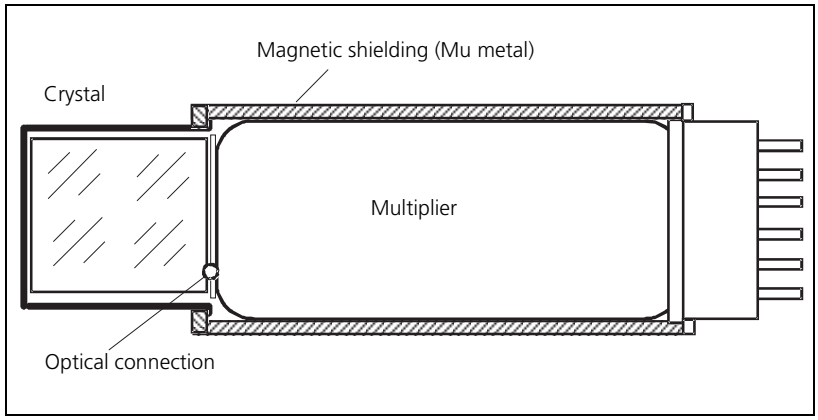


Fig. 4-4 Crystal-multiplier assembly

The crystal must be perfectly clear inside and not show any cracks or dull areas. The normal coloring is slightly greenish. A yellowish to brownish coloring is a sign of thermal overload and indicates that the crystal must be replaced.

The multiplier window is coated with a vapor-deposited layer acting as photo cathode. This layer gives the window a brownish tint similar to smoked glass. If this layer is no longer present or if it is stained, then the photo-cathode has been destroyed (e.g. by overheating, glass breakage, or incident light). The multiplier must be replaced. Faults caused by damage to the dynode systems (e.g. by excessive vibration) cannot be identified by appearance. If in doubt, replace the multiplier.

Before re-assembly, apply a drop of pure silicon oil (Berthold Id.-Nr. 18844) between crystal and multiplier, and distribute it evenly by gentle rubbing to ensure a sound optical connection between the two components. Using the adhesive tape, replace the Mu-metal screen, making sure that it is only under light tension.

4.6 Customer Service

Customer service for BERTHOLD TECHNOLOGIES measuring systems is available in many countries outside Germany. For further information please visit our website www.Berthold.com.

If you do not know the phone number of your local service engineer, please call one of the following numbers at BERTHOLD TECHNOLOGIES:

+49 (0) 7081 177-111 (phone)
+49 (0) 7081 177-339 (fax)
+49 (0) 7081 177-0 (switchboard))

e-mail: Service@Berthold.com

To get efficient help you have to provide the following information:

- Detector type or "LB" number, e.g. LB 480
- Information on the error
- Information on the application
  - Product being measured
  - Installation situation
  - Measuring system, e.g. limit switch, point source with CrystalSENS
- Parameter listing
- Source number and/or BERTHOLD TECHNOLOGIES commission number
- Contact person and phone number

4.7 Repair, Return Shipping

4.7.1 Electronics, Detector

If you intend to return parts or complete detectors for repair, please provide the following information:

- Detector type or "LB" number, e.g. LB 480
- Information on the error
- Delivery address
- Billing address
- Your order number (if necessary)
- Preferred mode of transportation (if necessary)
- Customs value (for cross-border shipment)

Delivery address of BERTHOLD TECHNOLOGIES:

BERTHOLD TECHNOLOGIES GmbH & Co. KG

Service Department

Calmbacher Str. 22

D-75323 Bad Wildbad

4.7.2 Source and Shielding

If source and/or shieldings have to be returned for repair, please contact the Supervisor of Transportation at BERTHOLD TECHNOLOGIES to clarify details:

+49 (0) 7081 177-219 (phone)

Please provide the following information:

- Name, address and telephone number of the Radiation Safety Officer
- Number of sources
- Source number(s)
- Isotope and activity
- Date of the last leak test
- State of the source(s) and the shielding(s)
- Information on the type of shielding, with which the source is to be transported (if available)
- Proforma invoice for the source and the shielding in which the source is returned (for customs purposes and only for cross-border transport)

The shipment is carried out either by a forwarder trained specifically for source transport or by air freight.

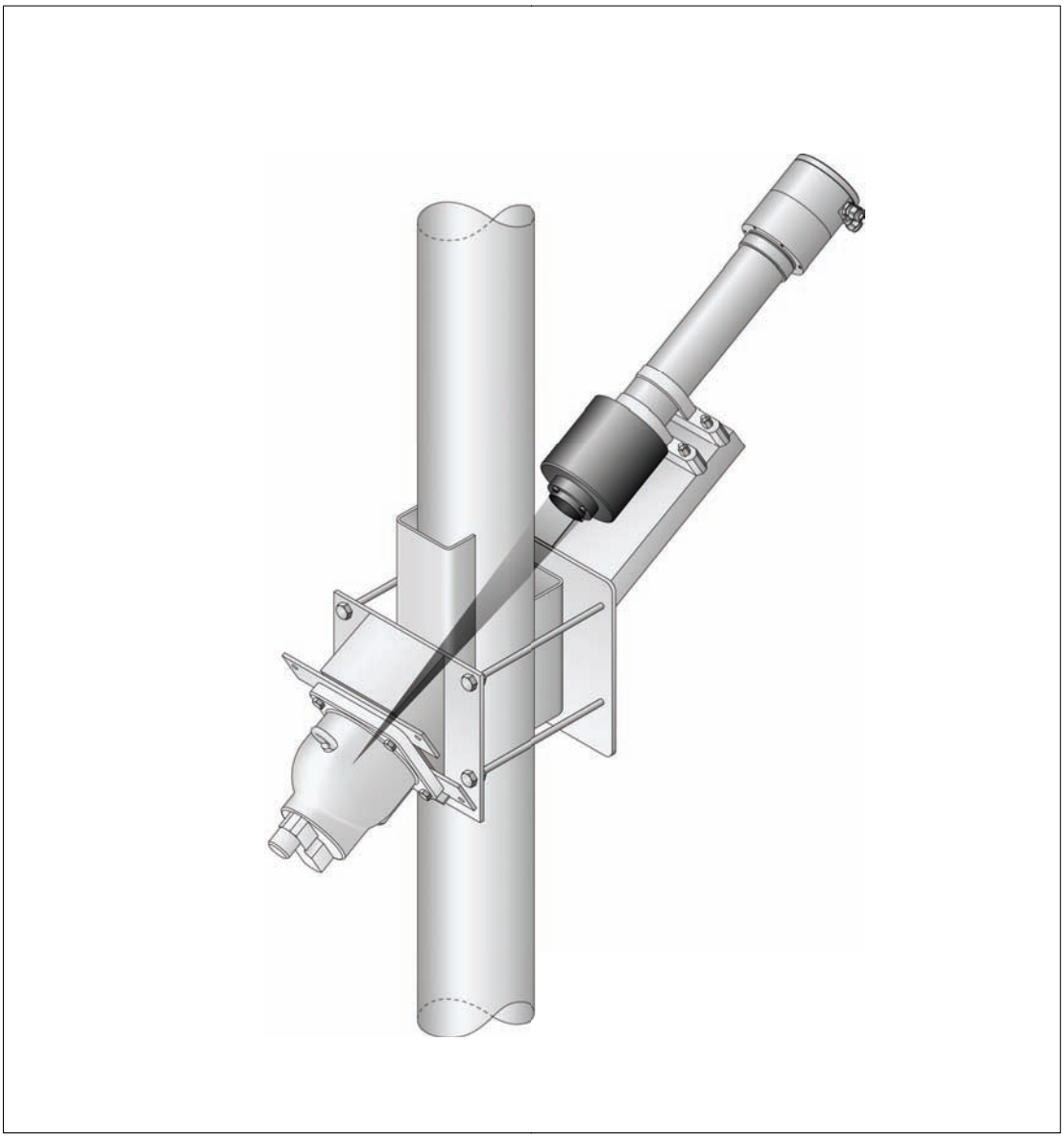
5 Technical Information

5.1 TI LB480 Density

Technical Information
Density LB 480

Density Gauge
Dichte Messung

Field mounted components
Messstellen-Komponenten

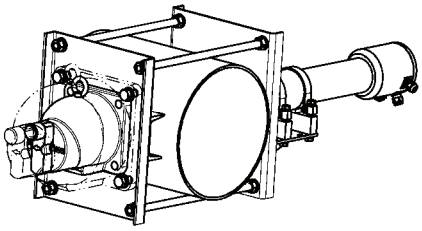


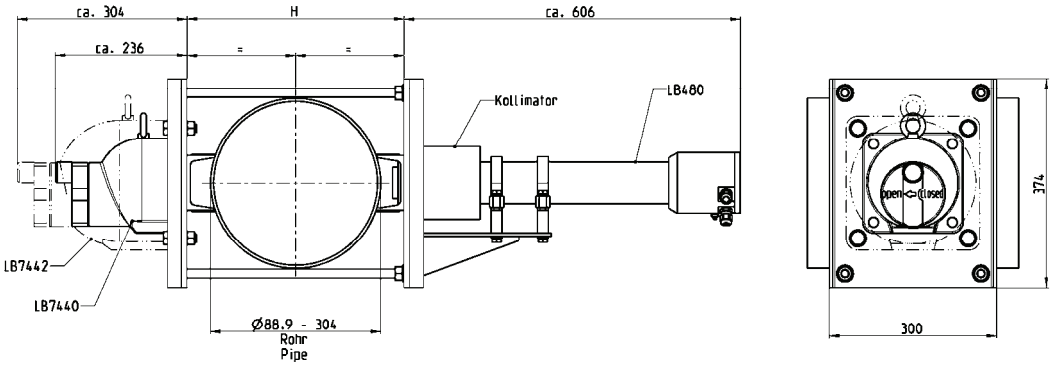
LB 480

Dimensions in mm
Abmessungen in mm

1.0 Clamping Device 90° for Pipe Diameter 88.9 … 304 mm
Montagevorrichtung 90° für Rohrdurchmesser 88.9 … 304 mm

Material	Carbon Seel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau





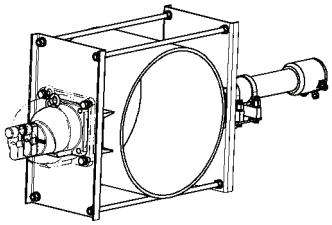
Part No. Id. Nr.	Pipe Diameter Rohrdurchmesser	H	Weight of Clamp. Device Gewicht der Montagevorrichtung
80795	88.9 101.6 114.3 141.3 168.3 219.1 273.0 304.0	120 156 180 218 250 310 368 402	23 kg

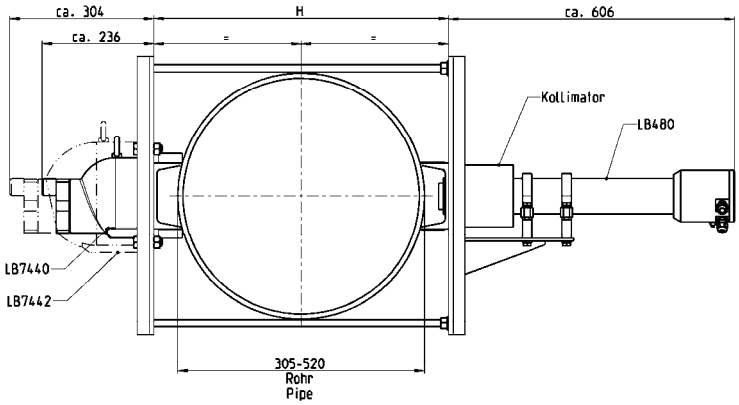
LB 480

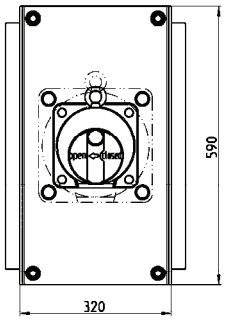
Dimensions in mm
Abmessungen in mm

1.1 Clamping Device 90° for Pipe Diameter 305 … 521 mm
Montagevorrichtung 90° für Rohrdurchmesser 305 … 521 mm

Material	Carbon Seel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau







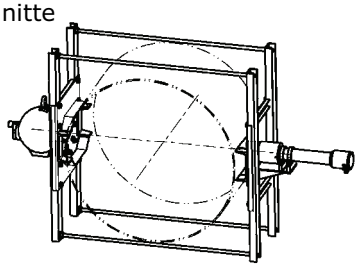
Part No. Id. Nr.	Pipe Diameter Rohrdurchmesser	H	Weight of Clamp. Device Gewicht der Montagevorrichtung
80796	305.0 318.0 323.8 355.6 406.4 457.2 508.0 521.0	400 413 419 451 501 552 603 616	34 kg

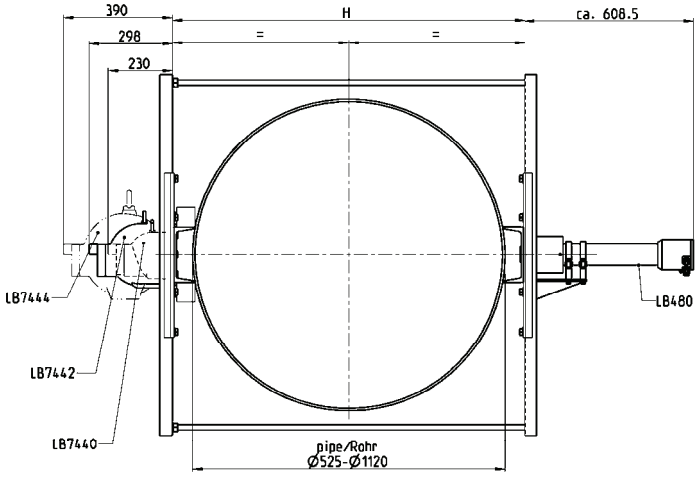
LB 480

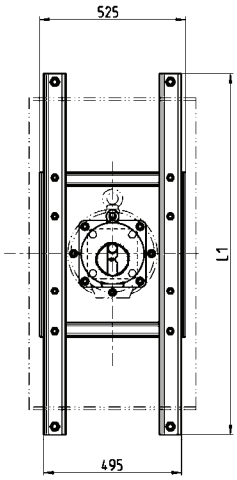
Dimensions in mm
Abmessungen in mm

1.2 Clamping Device 90° for Large Pipe Diameters
Montagevorrichtung 90° für große Rohrleitungsquerschnitte

Material	Carbon Seel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau





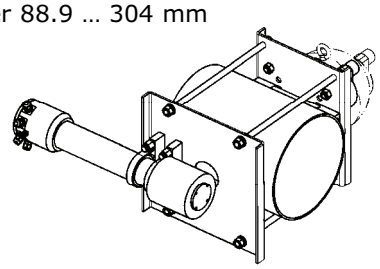


Part No. Id. Nr.	Pipe Ø Range Rohr Ø Bereich	H	L	L1	Weight of Clamp. Device Gewicht der Montagevorrichtung
51872-01	**400 ... 519**	643	735	680	76 kg
51872-02	**520 ... 559**	686	790	680	77 kg
51872-03	**560 ... 659**	792	890	740	79 kg
51872-04	**660 ... 759**	896	990	840	84 kg
51872-05	**760 ... 869**	1009	1100	950	89 kg
51872-06	**870 ...1020**	1163	1250	1200	98 kg
51872-07	**1020 ...1120**	1265	1350	1300	103 kg

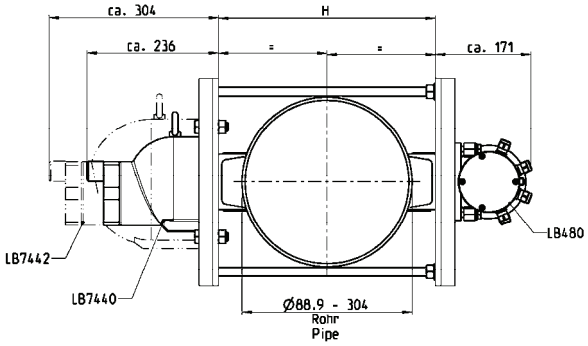
LB 480

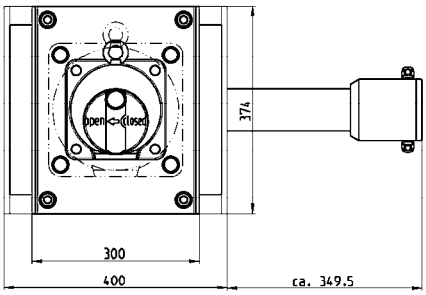
Dimensions in mm
Abmessungen in mm

2.0 Parallel Clamping Device 90° for Pipe Diameter 88.9 … 304 mm
Parallele Montagevorrichtung 90° für Rohrdurchmesser 88.9 … 304 mm



Material	Carbon Seel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau





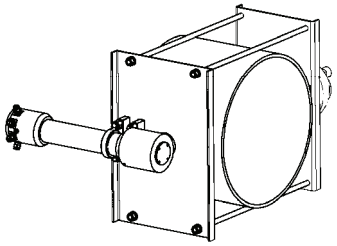
Part No. Id. Nr.	Pipe Diameter Rohrdurchmesser	H	Weight of Clamp. Device Gewicht der Montagevorrichtung
59296	88.9 101.6 114.3 141.3 168.3 219.1 273.0 304.0	120 156 180 218 250 310 368 402	22 kg

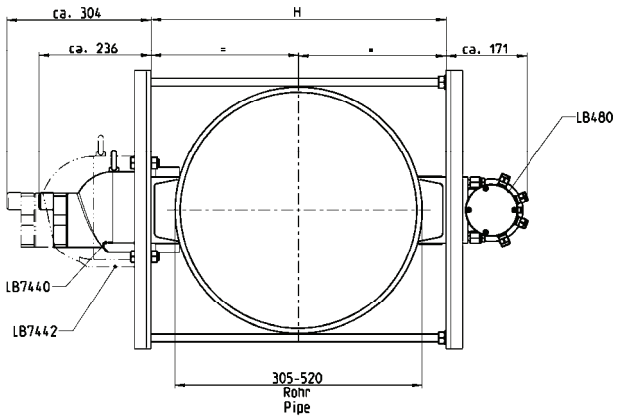
LB 480

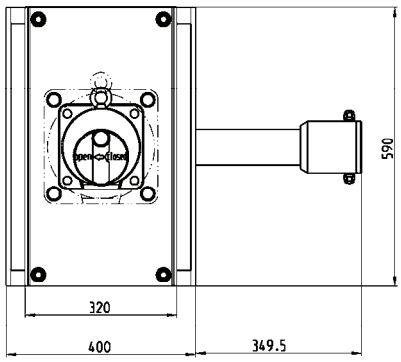
Dimensions in mm
Abmessungen in mm

2.1 Parallel Clamping Device 90° for Pipe Diameter 305 … 521 mm
Parallele Montagevorrichtung 90° für Rohrdurchmesser 305 … 521 mm

Material	Carbon Seel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau





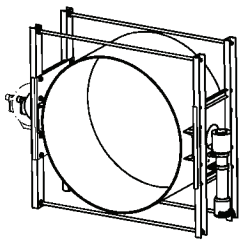


Part No. Id. Nr.	Pipe Diameter Rohrdurchmesser	H	Weight of Clamp. Device Gewicht der Montagevorrichtung
59293	305.0 318.0 323.8 355.6 406.4 457.2 508.0 521.0	400 413 419 451 501 552 603 616	34 kg

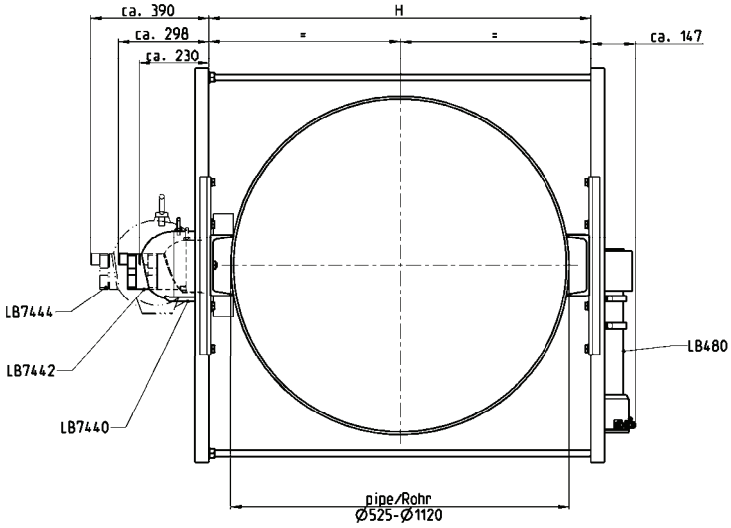
LB 480

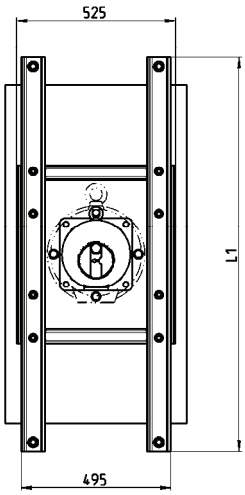
Dimensions in mm
Abmessungen in mm

2.2 Clamping Device 90° for Large Pipe Diameters
Montagevorrichtung 90° für große Rohrleitungsquerschnitte



Material	Carbon Seel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau





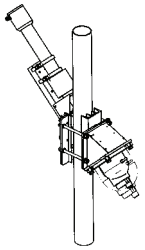
Part No. Id. Nr.	Pipe Ø Range Rohr Ø Bereich	H	L	L1	Weight of Clamp. Device Gewicht der Montagevorrichtung
81491-01	**400 ... 519**	643	735	680	73kg
81491-02	**520 ... 559**	686	790	680	74 kg
81491-03	**560 ... 659**	792	890	740	76 kg
81491-04	**660 ... 759**	896	990	840	79 kg
81491-05	**760 ... 869**	1009	1100	950	86 kg
81491-06	**870 ...1020**	1163	1250	1200	95 kg
81491-07	**1020 ...1120**	1265	1350	1300	100 kg

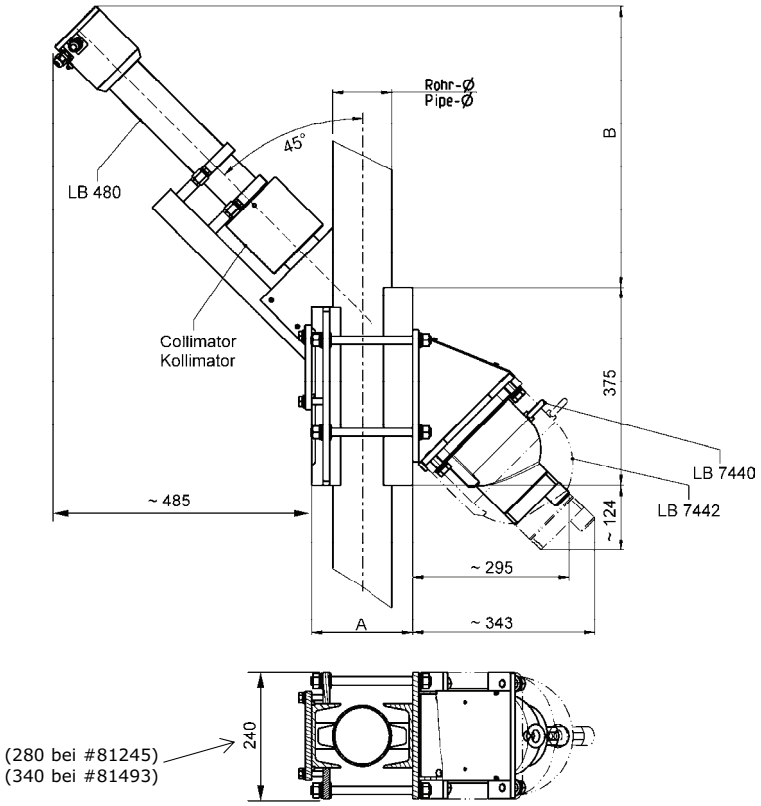
LB 480

Dimensions in mm
Abmessungen in mm

3.0 Clamping Device 45°
Montagevorrichtung 45°

Material	Carbon Seel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau





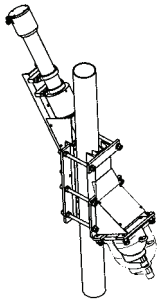
Part No. Id. Nr.	Pipe Ø	A	B	Weight approx Gewicht ca
27249	**48.3**	128	470	
27248	**60.3**	128	470	
27250	**63.5**	133	475	
27251	**70.0**	142	484	
27252	**76.1**	149	490	
27253	**82.5**	157	498	
27254	**88.9**	165	506	31 kg
27255	**95.0**	172	512	
27256	**101.6**	179	519	
27257	**108.0**	187	526	
27258	**114.3**	194	533	
80794	**121.0**	201	540	

Part No. Id. Nr.	Pipe Ø	A	B	Weight approx Gewicht ca.
80793	**127.0**	165	513	
26997	**133.0**	177	524	
26998	**139.7**	189	535	
26999	**146.0**	199	545	
27000	**152.4**	209	553	
27001	**159.0**	219	563	
27002	**165.1**	227	571	30 kg
27003	**168.3**	232	575	
27004	**171.0**	235	579	
27005	**177.8**	244	588	
27006	**191.0**	261	604	
81245	**220.0**	296	636	
81493	**273.0**	356	696	

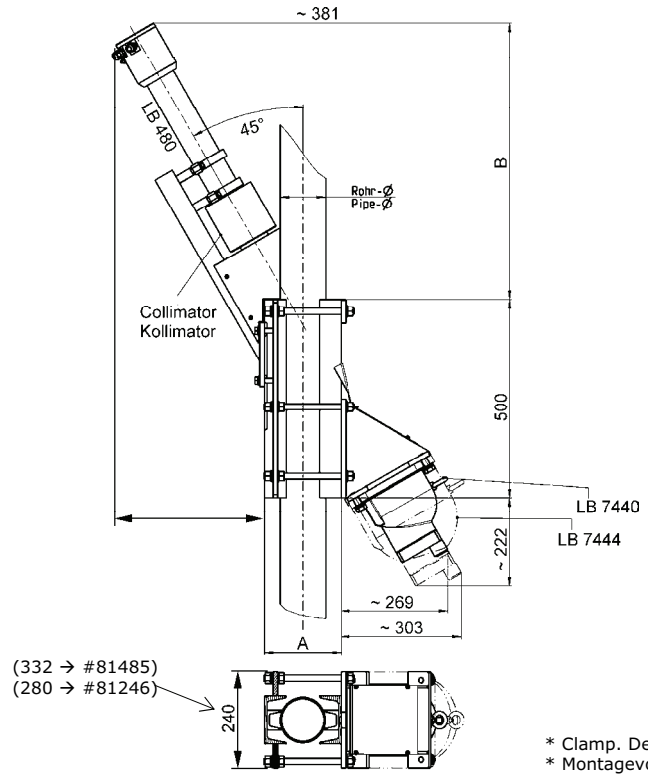
LB 480

Dimensions in mm
Abmessungen in mm

3.1 Clamping Device 30°
Montagevorrichtung 30°



Material	Carbon Seel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau



* Clamp. Device Weight (kg)
* Montagevorrichtung Gewicht (kg)

Part No. Id. Nr.	Pipe Ø	A	B	Weight* Gewicht*
25964	**48.3**	128	589	
80792	**60.3**	128	589	
25971	**63.5**	133	597	
25972	**70.0**	142	612	
25973	**76.1**	149	623	
25974	**82.5**	157	637	
25975	**88.9**	165	650	39 kg
25976	**95.0**	172	661	
25977	**101.6**	179	673	
25978	**108.0**	187	685	
25979	**114.3**	194	697	
25980	**121.0**	201	710	

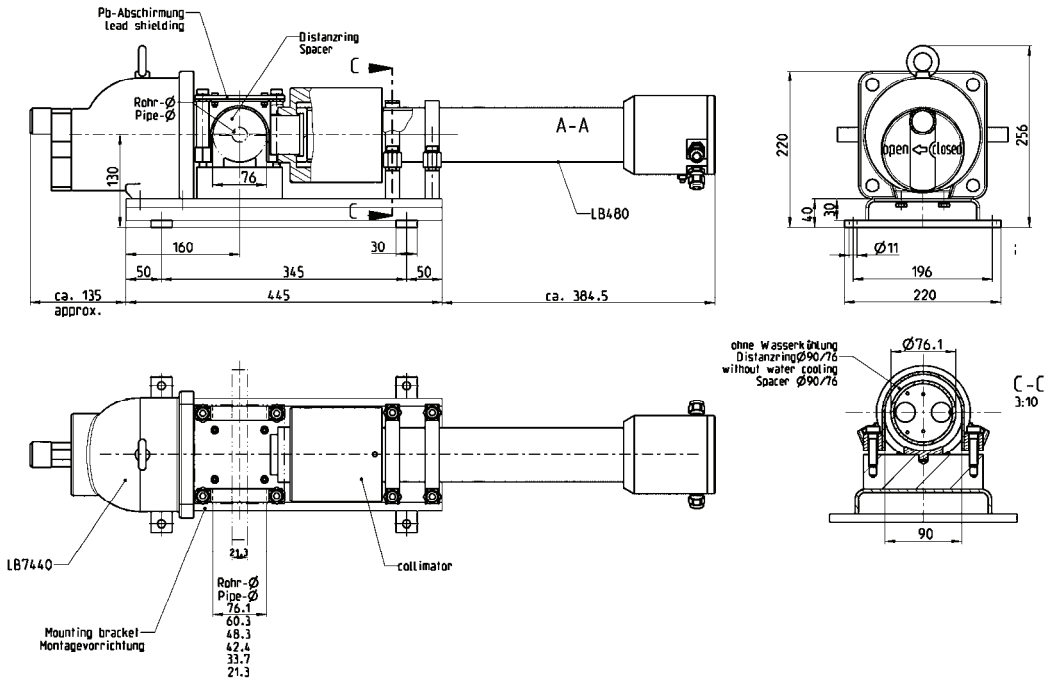
Part No. Id. Nr.	Pipe Ø	A	B	Weight* Gewicht*
80791	**127.0**	165	661	
26655	**133.0**	177	679	
26656	**139.7**	189	699	
26657	**146.0**	199	715	
26658	**152.4**	209	728	
26659	**159.0**	219	746	39 kg
26660	**165.1**	227	760	
26661	**168.3**	232	767	
26662	**171.0**	235	774	
26663	**177.8**	244	790	
26664	**191.0**	261	817	
81246	**220.0**	296	871	40 kg
81485	**273.0**	356	975	

LB 480

Dimensions in mm
Abmessungen in mm

4.0 Clamping Device 90° for Small Pipe Diameters
Montagevorrichtung 90° für kleine Rohrleitungsquerschnitte

Material	Carbon Seel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau



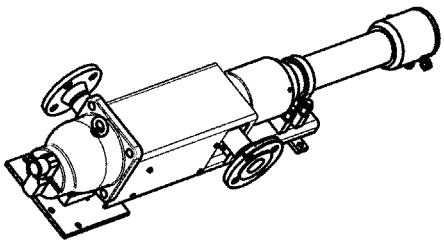
Part No. Id. Nr.	Pipe Ø	Weight of Clamp. Device Gewicht der Montagevorrichtung
47292-01 47292-02 47292-03 47292-04 47292-05 47292-06	**21.3** **33.7** **42.4** **48.3** **60.3** **76.1**	70 kg

LB 480

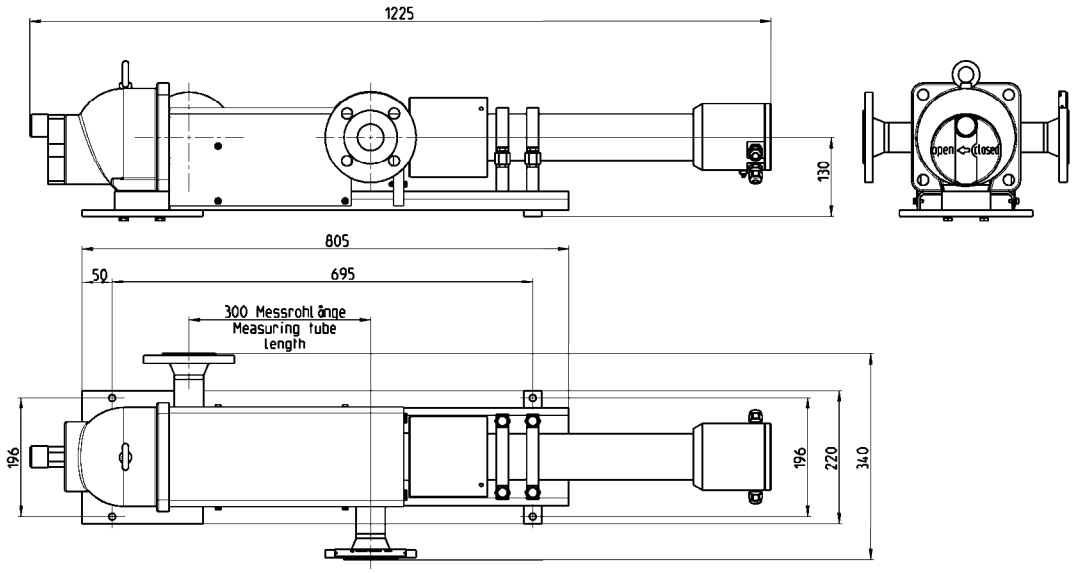
Dimensions in mm
Abmessungen in mm

4.1 S + U Pipe Clamping Device
S + U förmige Montagevorrichtung

Material	Carbon Seel Stahl St37
Painting Lackierung	Polyurethane, gray Polyurethan, grau



Part No. / Id. Nr. 21087



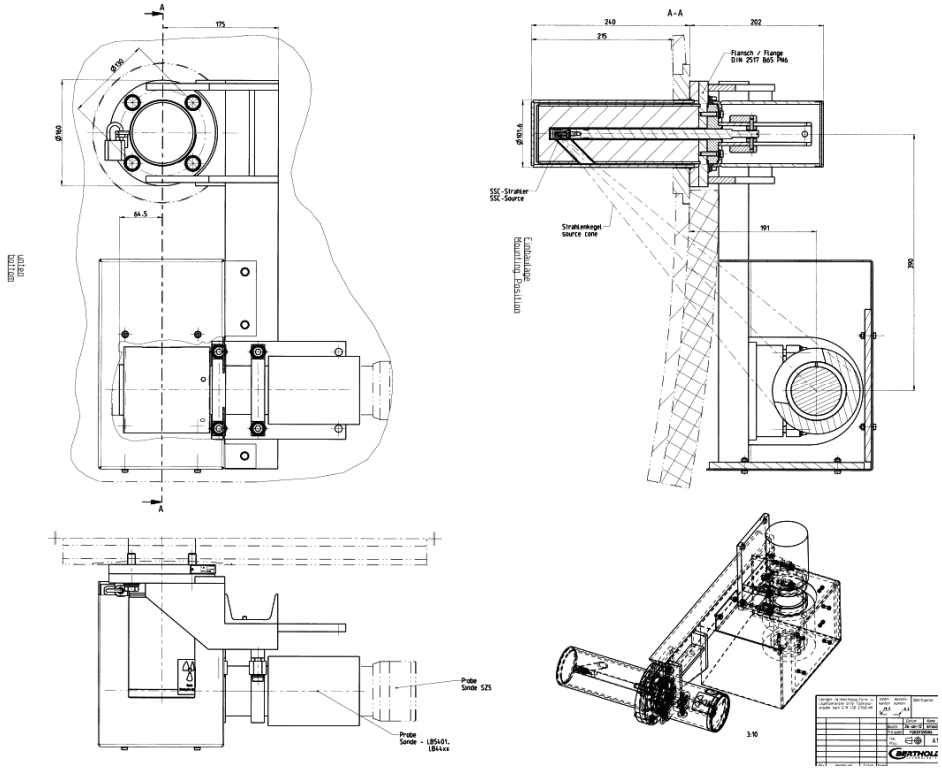
Verschiedene Versionen erhältlich. Obige beispielhafte Abbildung zeigt die Messstrecke in: - S-Form - DN40 - Messrohrlänge 300 - PN16 - ohne Temp.-Fühler	**Various versions available.** The drawing above shows exemplarily a clamping device with: - S-shaped - DN40 - pipe length 300 - PN16 - without temp.-sensor

LB 480

Dimensions in mm
Abmessungen in mm

5.0 Immersion Shielding
Tauchabschirmung

Material Dip Pipe Material Tauchrohr	Stainless Steel AISI 316Ti 1.4571
Painting Lackierung	Polyurethane, gray Polyurethan, grau



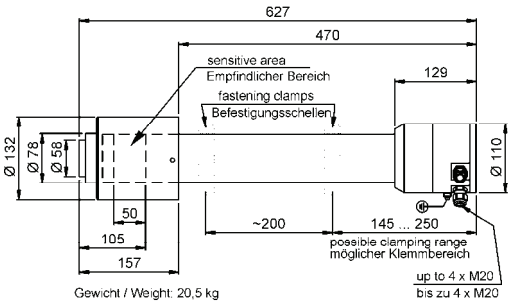
Part No. Id. Nr.	Measuring Range Messbereich
58959-01	depending on der vessel diameter

LB 480

Dimensions in mm
Abmessungen in mm

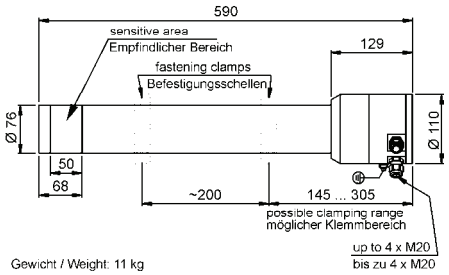
6.0 CrystalSENS

LB 480-11-..-r.-



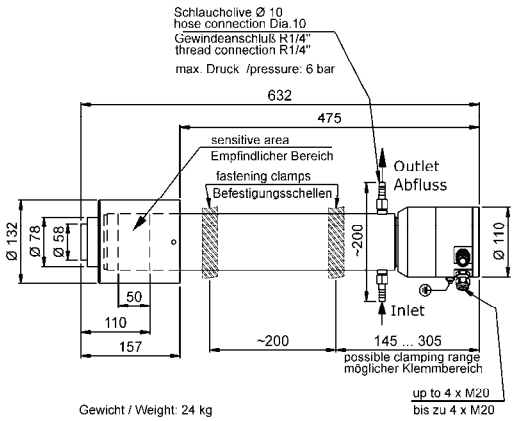
Gewicht / Weight: 20,5 kg

LB 480-11-..-0.-



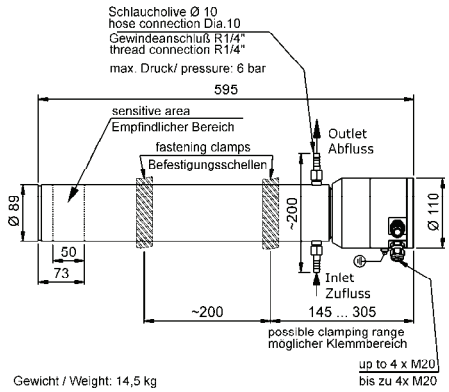
Gewicht / Weight: 11 kg

LB 480-12-..-r.-



Gewicht / Weight: 24 kg

LB 480-12-..-0.-



Gewicht / Weight: 14,5 kg

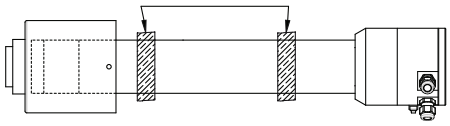
Type Typ	Weight Gewicht	Collimator Kollimator
LB 480-11-..-r.-	21 kg	✓
LB 480-11-..-0.-	11.5 kg	–
LB 480-12-..-r.-	24,5 kg	✓
LB 480-12-..-0.-	15 kg	–

*WC/WK = Water Cooling / Wasserkühlung

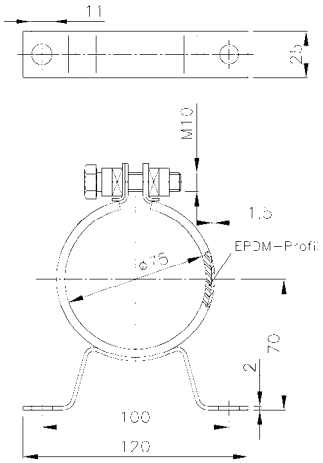
LB 480

Dimensions in mm
Abmessungen in mm

6.1 Mounting Clamps for Detector
Befestigungsschellen für Detektor



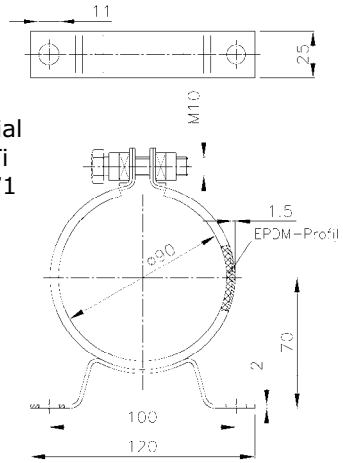
for Detectors without water cooling
für Detektoren ohne Wasserkühlung



Id. Nr. 31346 (1 set = 2 clamps)
Id. Nr. 31345 (single clamp)

Material
316Ti
1.4571

for Detectors with water cooling
für Detektoren mit Wasserkühlung



Id. Nr. 31347 (1 set = 2 clamps)
Id. Nr. 31344 (single clamp)

position for the clamps, see detector drawing
Position für die Schellen-Befestigung siehe Detektor-Zeichnung

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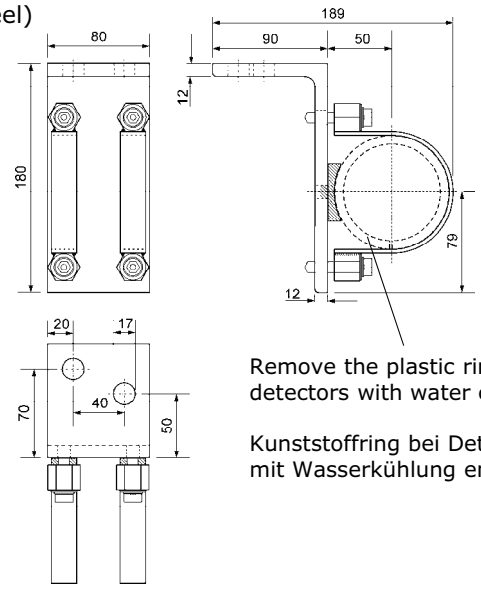
Heavy Duty Detector Holder (stainless steel)
Robuste Detektor Halterung (Edelstahl)

Part No. Id. Nr.	for Detector für Detektor
39246	without water cooling ohne Wasserkühlung
39247	with water cooling mit Wasserkühlung



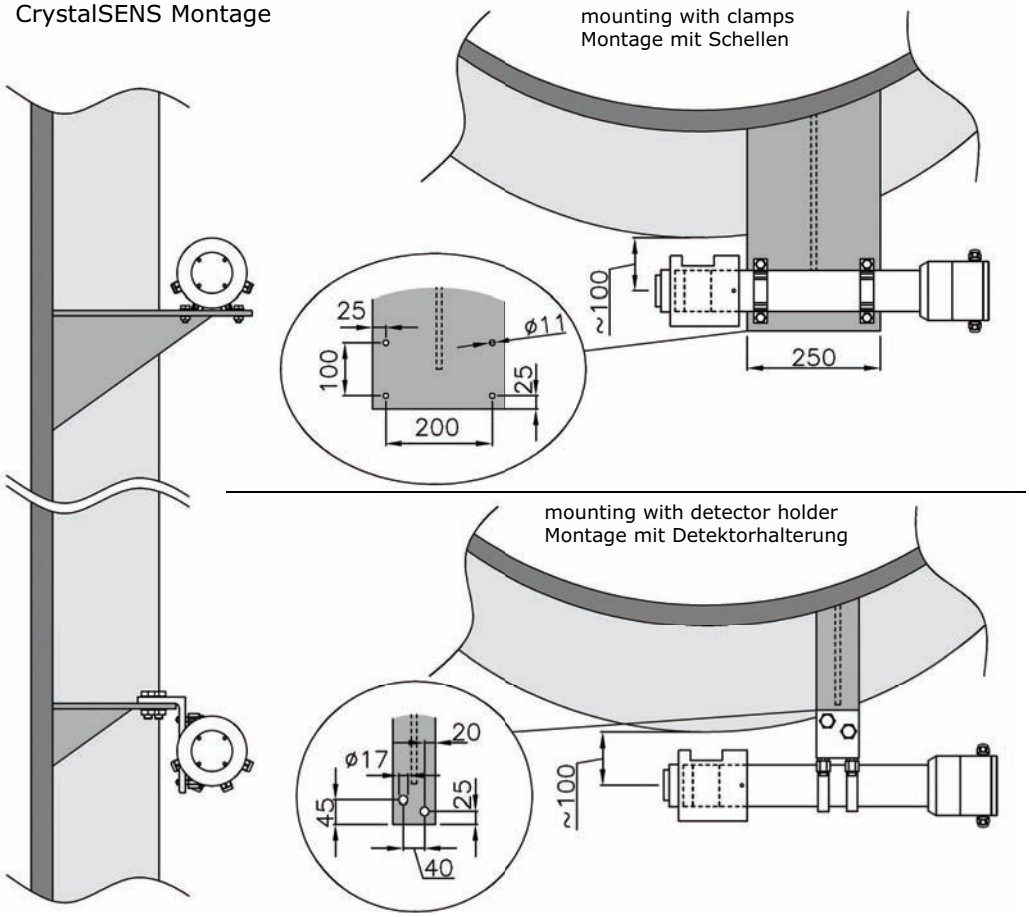
Remove the plastic ring for detectors with water cooling.

Kunststoffring bei Detektoren mit Wasserkühlung entfernen.

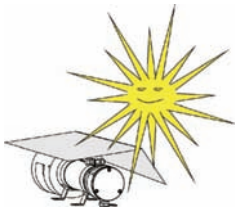
LB 480

Dimensions in mm
Abmessungen in mm

6.2 CrystalSENS Mounting
CrystalSENS Montage



6.3 Sun Roof against Strong Sun Radiation
Sonnendach gegen starke Sonneneinstrahlung



Direct sun radiation can overheat the detector. If the detector temperature can reach more than 50°C, a suitable sun roof must be installed.
The heating of the detector by thermal radiation from the vessel can also be moderated by a thermal sheet, e.g. by a thin metal plate.
For each detector a water cooling (option) is available.

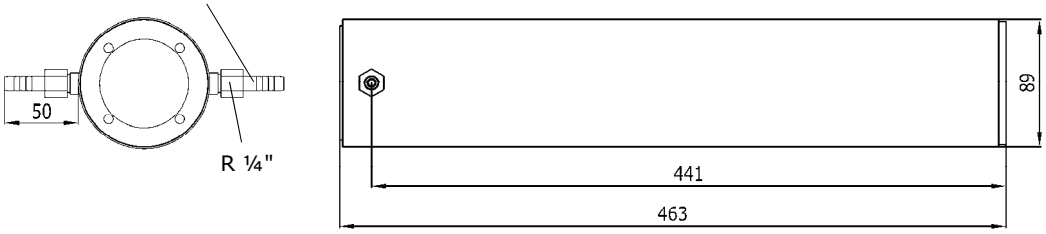
Wird durch Sonneneinstrahlung eine Detektortemperatur von über 50°C erreicht, so ist ein geeigneter Sonnenschutz zu montieren.
Auch die Aufheizung des Detektors durch Wärmeabstrahlung vom Behälter kann durch ein dünnes Wärmeableitblech gemildert werden.
Für jeden Detektor steht auch eine geeignete Wasserkühlung (Option) zur Verfügung.

LB 480

Dimensions in mm
Abmessungen in mm

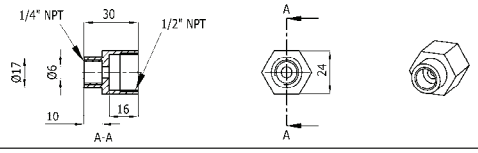
6.4 CrystalSENS Water Cooling Jacket and Adaptor Fittings
CrystalSENS Wasserkühlung und Adapter Anschlussstücke

pipe connection diameter 10
Schlauchanschluss Ø 10



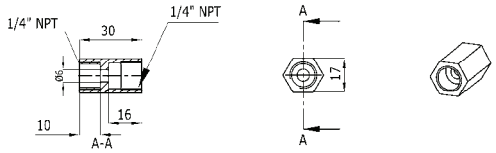
Fitting adaptor for standard water cooling Rp ¼" → ½" NPT
stainless steel 304, part no: 47189

Adapter für Standard Wasserkühlung Rp ¼"→ ½" NPT
Edelstahl 1.4301, Id. Nr.: 47189



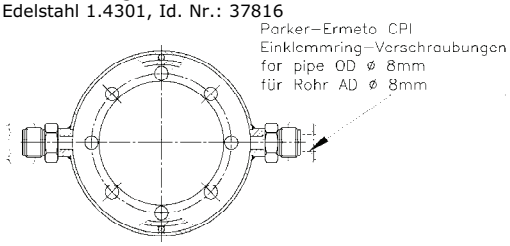
Fitting adaptor for standard water cooling Rp ¼> ¼" NPT
stainless steel 304, part no: 46743

Adapter für Standard Wasserkühlung Rp ¼> ¼" NPT
Edelstahl 1.4301, Id. Nr.: 46743



Water cooling jacket with Parker Ermeto Fittings
stainless steel 304, part no: 37816

Wasserkühlung mit Parker Ermeto Anschlüssen
Edelstahl 1.4301, Id. Nr.: 37816



Further fitting adaptors for standard water cooling jacket:
Rp ¼"> ½" NPT male, stainless steel 304, part no: 06352
Rp ¼"> ¼" NPT male, stainless steel 304, part no: 06349
Weitere Adapter für die Standard-Wasserkühlung:
Rp ¼"> ½" NPT Außengewinde, 1.4301, Id. Nr.: 06352
Rp ¼"> ¼" NPT Außengewinde, 1.4301, Id. Nr.: 06349

The above mentioned water cooling jackets and adaptor fittinigs offers following connection versions:
Die oben aufgeführten Wasserkühlungen und Adapter ermöglichen folgende Anschlussvarianten:

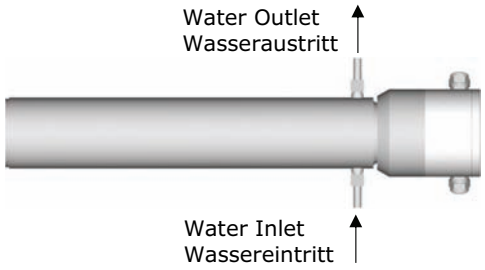
Fitting Connection	**Anschluss-Stutzen**	**part no. (material) Id.Nr. (Werkstoff)**
R ¼" pipe connection, male European standard Whitworth pipe thread	R ¼" Außengewinde für Rohrverschraubung europäisches Standard Whitworth-Rohrgewinde	21326 (304/1.4301) 38055 (Carbon Steel St37)
10 mm hose connection for water hose connection ID 10 mm	Schlauchstutzen für Schlauch- Innendurchmesser 10 mm	21326 (304/1.4301) 38055 (Carbon Steel St37)
fitting adaptor ½" NPT female	Adapter mit ½" NPT Innengewinde	47189 (304/1.4301)
fitting adaptor ¼" NPT female	Adapter mit ¼" NPT Innengewinde	46743 (304/1.4301)
fitting adaptor ½" NPT male	Adapter mit ½" NPT Außengewinde	06352 (304/1.4301)
fitting adaptor ¼" NPT male	Adapter mit ¼" NPT Außengewinde	06349 (304/1.4301)

LB 480

Dimensions in mm
Abmessungen in mm

6.5 Water Cooling Installation Instruction
Anweisung zur Installation der Wasserkühlung

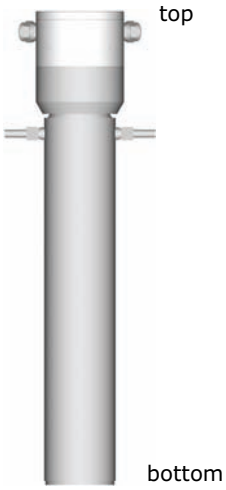
Horizontal Detector Installation
Horizontale Detektor Installation



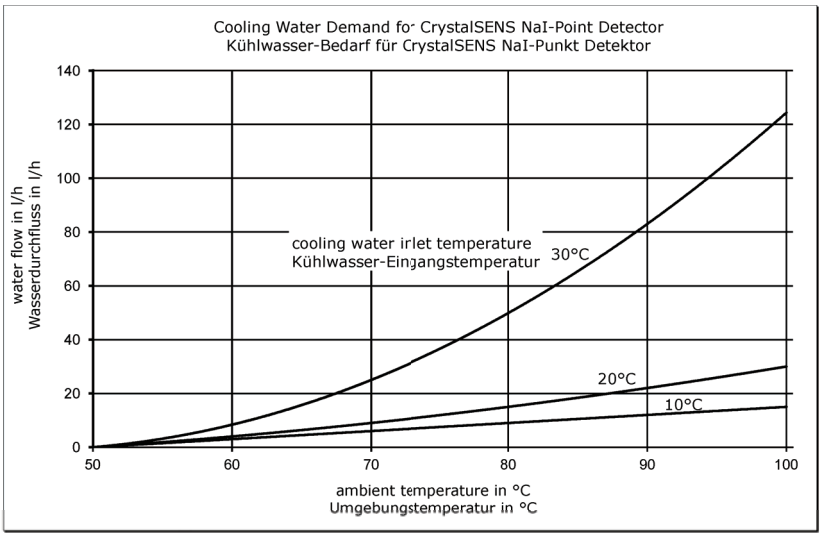
In order to fill the entire water cooling jacket, incoming water must enter from the bottom.
Damit sich die Wasserkuhlung vollständig mit Wasser füllt, muss der Wasserzufluss von unten erfolgen.

Vertical Detector Installation
Vertikale Detektor Installation

Install the Detector with the connection at the top.
Installieren Sie den Detektor mit dem Anschlussgehäuse oben.



6.6 Detector Cooling Water Demand
Detektor Kühlwasserbedarf

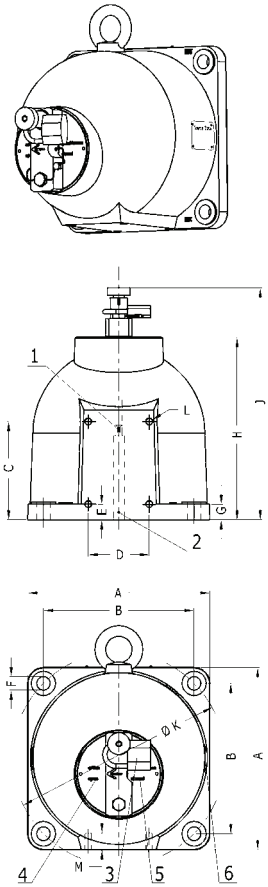


LB 480

Dimensions in mm
Abmessungen in mm

7.0 Point Source Shielding LB 744x
Punktstrahler-Abschirmbehälter LB 744x

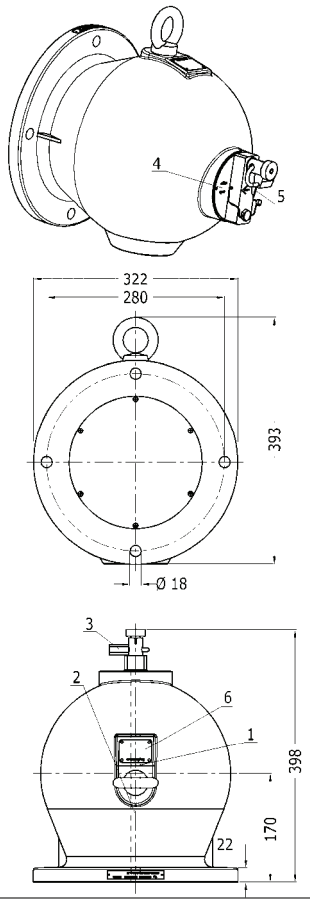
LB 7440 / 7442 / 7445 / 7446



1 Strahler
2 Strahlenausgang
3 Schloss
4 Position **Offen**
5 Position **Geschlossen**
6 Typenschild

1 Point Source
2 Radiation Exit
3 Lock
4 Position **Open**
5 Position **Closed**
6 Type Label

LB 7444



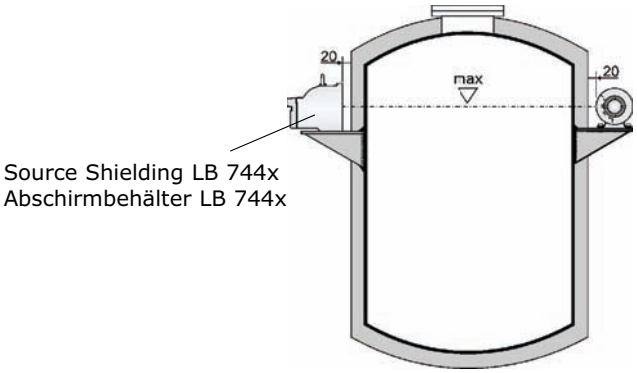
Type Typ	Housing Gehäuse	A	B	C	D	E	FØ	G	H	J	KØ	L	M	Flange Flansch	⟨	kg
LB 7440-F-CR LB 7445-F-CR	Carbon Steel St 37	180	142	75	60	15	18	20	173	238	200	M8	12	ND 125 PN 6	16°	31
LB 7440-FE-CR LB 7445-FE-CR	AISI 439 1.4510															
LB 7442-F-CR LB 7446-F-CR	Carbon Steel St 37	240	198	130	80	20	18	20	242	306	280	M10	14	ND 200 PN 6	9°	81
LB 7442-FE-CR	AISI 439 1.4510															
LB 7444-CR	Carbon Steel St 37													ND 200 PN 6	6°	170

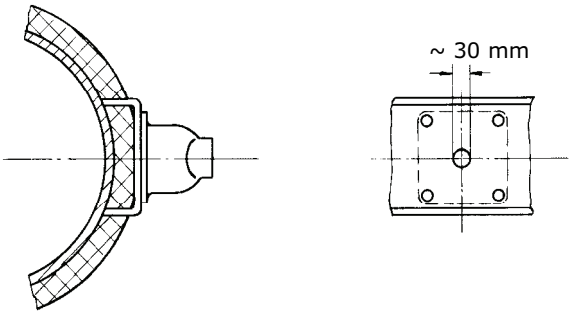
⟨ Radiation Angle of the Shielding / Abstrahlwinkel der Abschirmung

LB 480

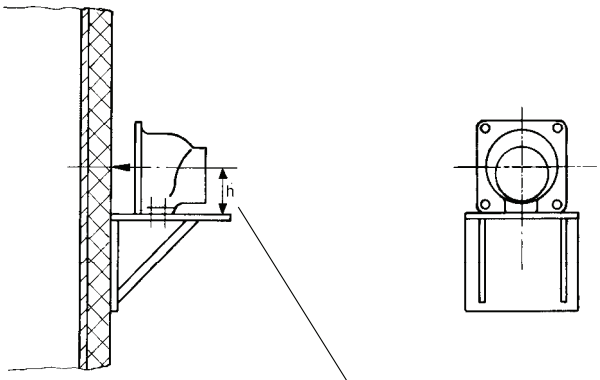
Dimensions in mm
Abmessungen in mm

7.1 Mounting Proposal for Source Shielding LB 744x
Montagevorschlag für Abschirmbehälter LB 744x





Flange Installation
Flanschinstallation



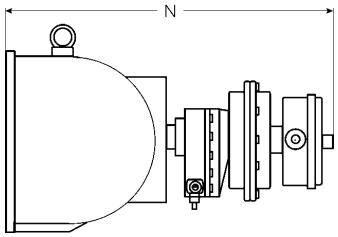
Pedestal Installation
Sockelinstallation

	LB 7440 LB 7445	LB 7442 LB 7446	LB 7444
h	90	120	161

LB 480

Dimensions in mm
Abmessungen in mm

7.2 Pneumatic Actuator for Source Shielding LB 744x
Pneumatischer Verschlussantrieb für Abschirmbehälter LB 744x



N approx / ca.	Type / Typ
390	LB 7440-F-CR LB 7440-D-CR LB 7440-FE-CR LB 7440-DE-CR
460	LB 7442-F-CR LB 7442-D-CR LB 7442-FE-CR LB 7442-DE-CR
570	LB 7444-CR

Protection Schutz	Part No. Ident.	Description Beschreibung
IP 65	36119	Pneumatic Actuator with Limit Switch Pneumatischer Verschlussantrieb mit Endschalter
Ex de IIC T6	80919	Pneumatic Actuator with Limit Switch with ATEX Pneumatischer Verschlussantrieb mit Endschalter with ATEX

Technical Data for Pneumatic Actuator Technische Daten für pneumatischen Verschlussantrieb	
Compressed Air Druckluft	min. 4 x 105 Pa (4 bar) max. 4 x 105 Pa (7 bar) Connection / Anschluss: G 1/8
Air Quality Luftqualität:	clean as usual for air compressed tools, oil free Sauber wie für Druckluft-Werkzeuge üblich, ölfrei
Temperature Range Temperaturbereich:	-20°C … +80°C

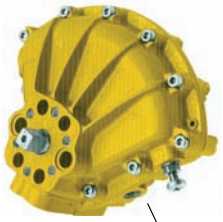
Limit Switch, Option for Signaling OFF / CLOSED Endschaltereinheit, Optionen für Signalisierung AUF / ZU	
Option I:	IP 65, 2 contacts (OFF/CLOSED) 48 V DC, 1A IP 65, 2 Kontakte (AUF/ZU) 48 V DC, 1A
Option II:	2 contacts (OFF/CLOSED) max. 250 V AC, 1A, Protection for internal micro switches: EEx d IIC T6 Housing protection: EEx e II T6 2 Kontakte (AUF/ZU) max. 250 V AC, 1A, Schutzart der Microeinbautaster: EEx d IIC T6 Gehäuseschutzart: EEx e II T6
Option III:	2 Proximity switches for intrinsically safe power supply 2 Näherungsinitiatoren für Eigensichere Speisung

LB 480

Dimensions in mm
Abmessungen in mm

7.3 Components for Pneumatic Actuator
Einzelteile für Pneumatischen Verschlussantrieb

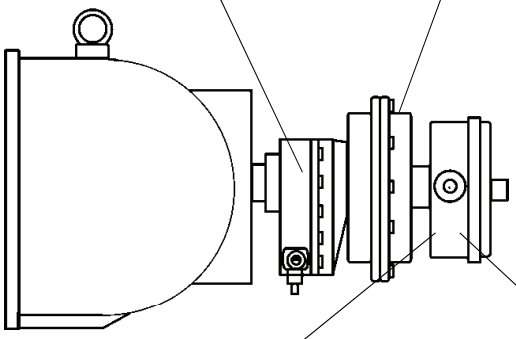
Pneumatic Actuator
Pneumatischer Antrieb

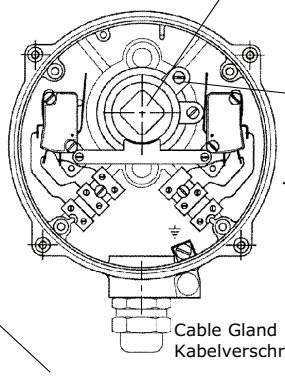


Return Spring
Rückstellfeder

male square spin-type handle
as position indicator, or for
manual operation

Außenvierkant zur Stel-
lungsanzeige, oder manueller
Betätigung





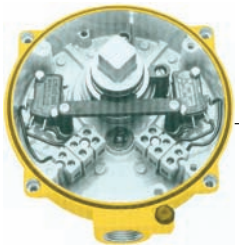
adjustable cam
verstellbare Nocken

Cable Gland
Kabelverschraubung

Limit Switch in Ex de
Endschaltereinheit in Ex de

Cable Diameter 6 … 12 mm
Kabeldurchmesser 6 … 12 mm

Limit Switch in IP 65
Endschaltereinheit in IP 65



Cable Diameter 9 … 12 mm
Kabeldurchmesser 9 … 12 mm

Contact Rating
Kontaktbelastbarkeit

Volt		Load / Last (A)	
AC	DC	R	L
250		7	5
125		7	5
	30	7	5
	75	1	1
	125	0,5	0,06
	250	0,25	0,03

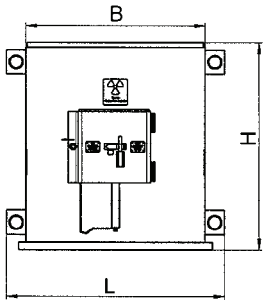
Contact Rating
Kontaktbelastbarkeit

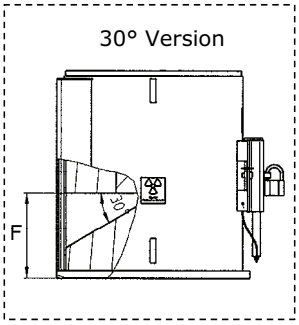
Volt		Load / Last (A)		
AC	DC	R	L	Lamp / Lampe
250		15	3	1,5
125		15	3	1,5
	12	15	3	1,5
	24	10	2	1
	48	3	0,6	0,3
	250	0,25	0,05	0,025

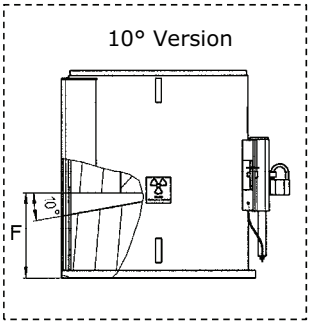
LB 480

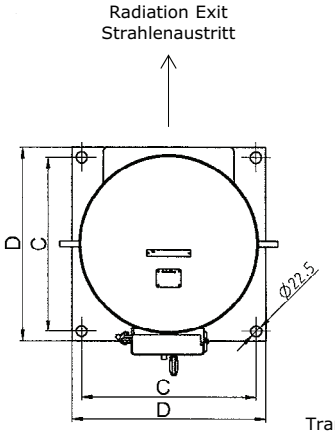
Dimensions in mm
Abmessungen in mm

7.4 Point Source Shielding LB 8030/8040
Punktstrahler-Abschirmbehälter LB 8030/8040

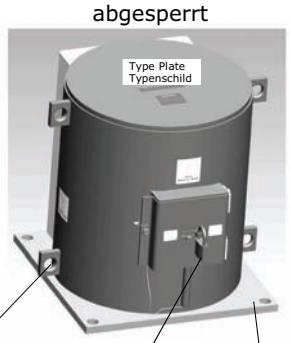




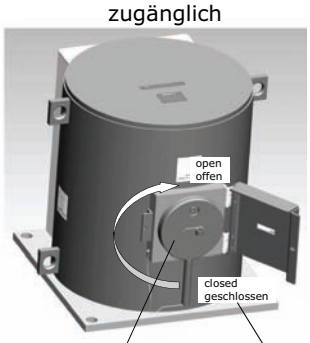




Shutter mechanism locked
Strahlermechanismus abgesperrt



Shutter mechanism accessible
Strahlermechanismus zugänglich



Transport Lug
Transportöse

Pad Lock
Vorhängeschloss

Mounting Flange
Montageflansch

Source Locking Mechanism
Strahlerverschluss-mechanismus

Source Position
Strahler Position

Material	Stainless Steel 304 Edelstahl 1.4301
Painting Lackierung	Polyurethane, yellow Polyurethan, gelb

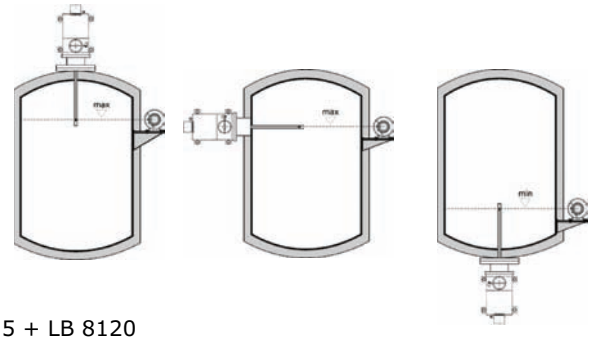
Type Typ	B	C	D	F	H	L	Flange Flansch	⟨	kg
LB 8030-01	370	360	400	305	425	450	ND 125 PN 6	30°	516
LB 8030-02								10°	
LB 8040-01	456	460	500	305	567	536	ND 200 PN 6	30°	1014
LB 8040-02								10°	

⟨ Radiation Angle of the Shielding / Abstrahlwinkel der Abschirmung

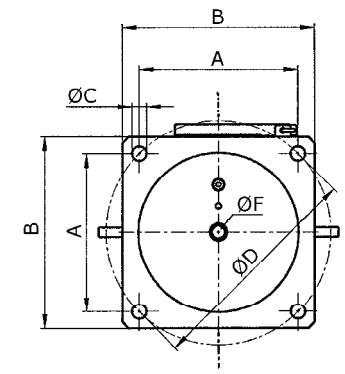
LB 480

Dimensions in mm
Abmessungen in mm

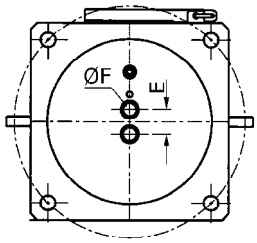
7.5 Point Source Flange Shielding LB 81xx for Dip Pipe Installations
Punktstrahler-Flansch-Abschirmbehälter LB 81xx für Tauchrohr-Applikationen

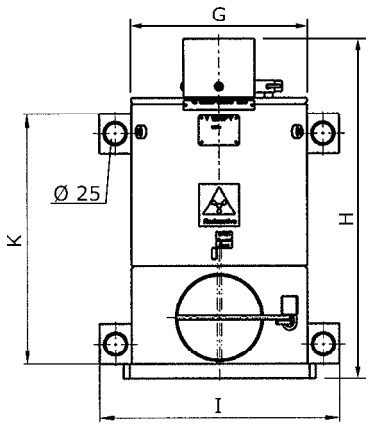


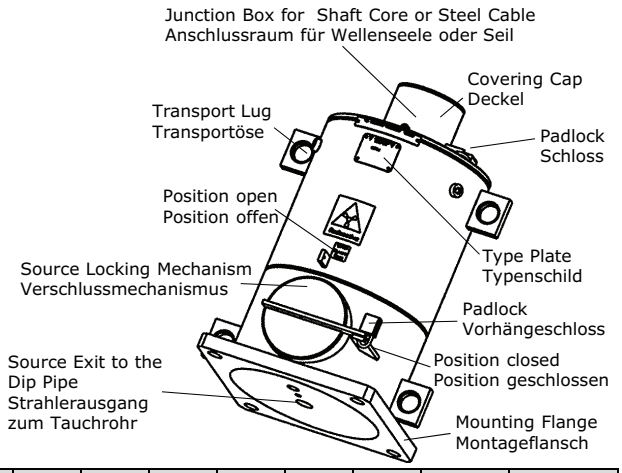
Type/Typ LB 8115 + LB 8120



Version for 2 Sources LB 81xx-20
Version für 2 Strahler LB 81xx-20





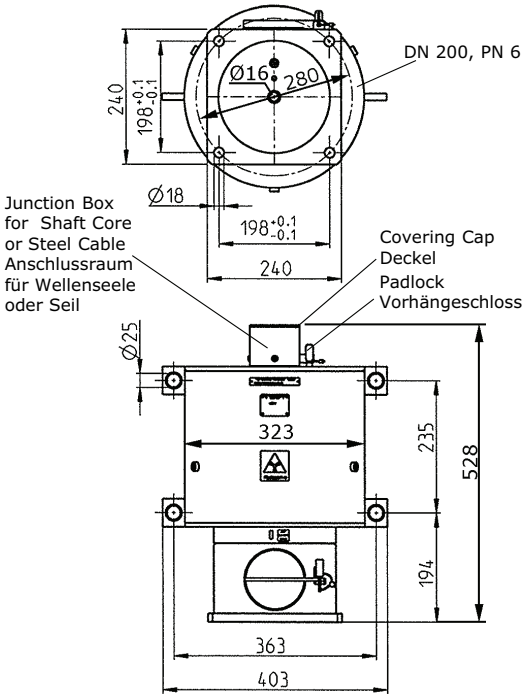


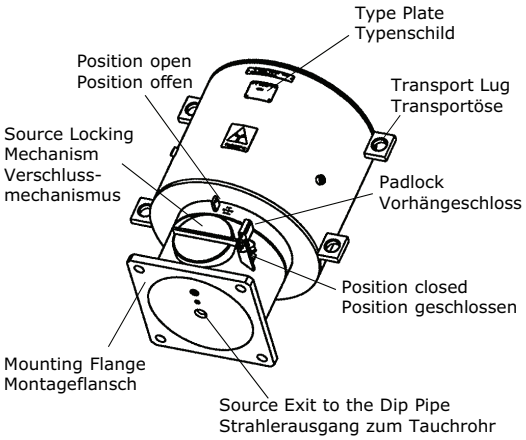
Type Typ	A	B	ØC	ØD	E	ØF	G	H	I	K	kg	Flange Flansch
LB 8115-01 LB 8115-20	141,5	180	18	200	- 30	16	159	350	239	237	60 kg	DN 125 PN 6
LB 8120-01 LB 8120-20	198	240	18	280	- 30	16	219	425 429	300	313	137 kg	DN 200 PN 6

LB 480

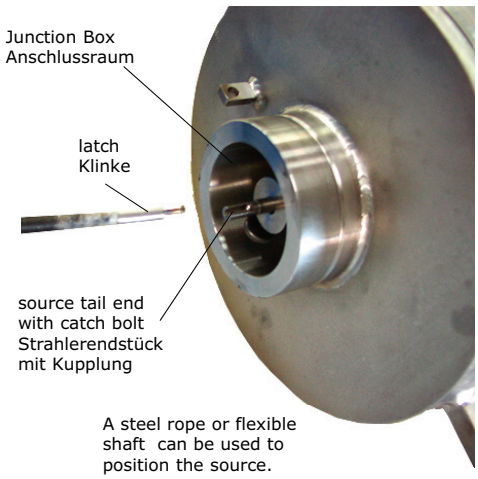
Dimensions in mm
Abmessungen in mm

Type/Typ LB 8125-01





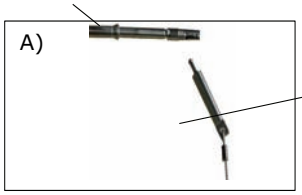
7.6 Operation of Flange Shielding
Bedienung der Flanschabschirmung



A steel rope or flexible shaft can be used to position the source.

Zur Positionierung kann ein Stahlseil oder eine Wellenseele genutzt werden.

source tail end with catch bolt
Strahlerendstück mit Kupplung



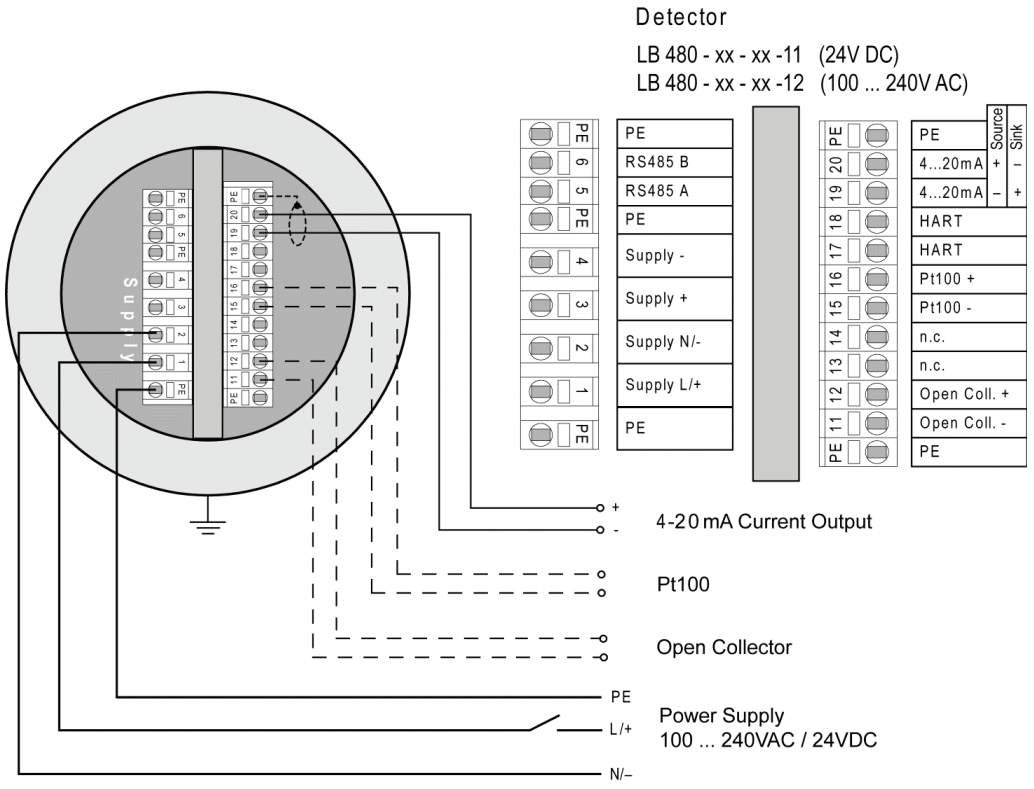
plug the latch into the catch bolt
Klinke in Kupplung einklinken

latch plugged into the catch bolt
Klinke in Kupplung einklinken

LB 480

Dimensions in mm
Abmessungen in mm

8.0 Terminal Connection
Elektrischer Anschlussplan



6

Accessories

6.1 Cable glands

The sealing of the screwed fittings on the cable can be made of several sealing rings, depending on the screwed fitting, which have to be adapted to the diameter of the cable. The sealing rings inserted into the screwed fittings allow a relatively large cable clamping area. Remove the sealing rings from the screwed fitting to adapt them to the cable diameter used. A list of screwed fittings available from BERTHOLD TECHNOLOGIES can be found in the manual for explosion protection on *page 1-34*.

The following is an example of a screwed cable gland with additional sealing ring for small cable diameters which must be removed for larger diameters.

Assembly instructions for ID No. 55412 and 56086

*blue*globe® – Montage
*blue*globe® – *Installation*

blueglobe® mit kleinem Kabeldurchmesser
Bei IP 68 Installationen globemarker® außenliegend

blueglobe® with small cable diameter
With IP 68 installations globemarker® on the outside

Abb. 1
Fig. 1

blueglobe® mit kleinem Kabeldurchmesser
oder globemarker® entfernen

blueglobe® with small cable diameter
or removing globemarker®

Abb. 2
Fig. 2

blueglobe® mit großem Kabeldurchmesser
Bei großem Kabeldurchmesser Inlet entfernen: Schraubendreher senkrecht in Trennnaht einstechen

blueglobe® with large cable diameter
With a large cable diameter – remove inlet. Insert screwdriver vertically into separating seam

Abb. 3
Fig. 3

blueglobe® mit großem Kabeldurchmesser
Inlet aushebeln

blueglobe® with large cable diameter
Lift out the inlet

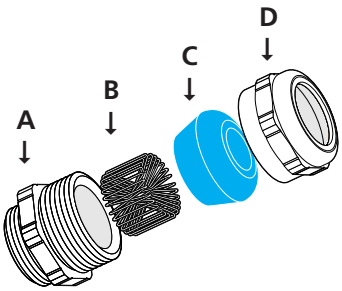
Abb. 4
Fig. 4

Assembly instructions for ID No. 56091

blueglobe TRI® – Montageanleitung
blueglobe TRI® – Assembly Instruction

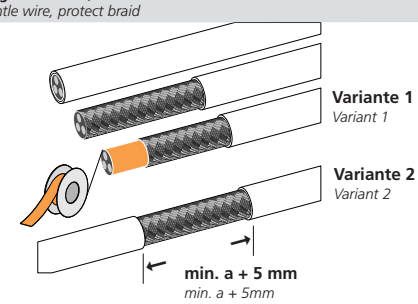
Übersicht Bestandteile
Overview components

Doppelnippel (A), Feder (B), Globe-Dichteinsatz (C), Druckschraube (D)
Double nipple (A), spring (B), globe-sealing insert (C), pressure screw (D)



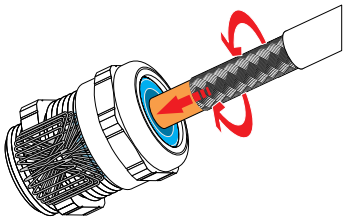
Schritt 1 – Vorbereitung der Montage
Step 1 – Prepare installation

Leitung abmanteln, Geflecht mit Isolierband schützen
Dismantle wire, protect braid



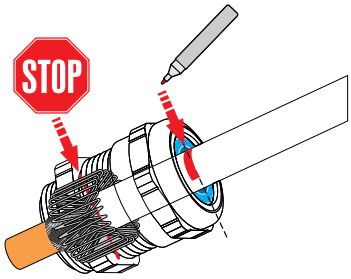
Schritt 2 – Montage
Step 2 – Installation

Kabel mit leichter Drehung einführen
Install cable with slight turn



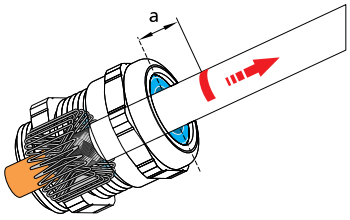
Schritt 3 – Montage
Step 3 – Installation

Markieren, wenn der Kabelmantel die Feder berührt
Mark when cable sheath touches spring



Schritt 4 – Montage
Step 4 – Installation

Kabel gemäß Maß a zurückziehen (siehe Tabelle unten)
Withdraw cable acc. size a (see table)



Schritt 5 – Montage
Step 5 – Installation

Druckschraube mit Drehmoment festziehen (siehe Tabelle unten)
Fix pressure screw with nominal torque (see table)

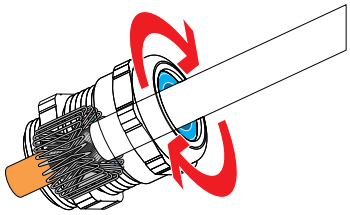


Tabelle
Table

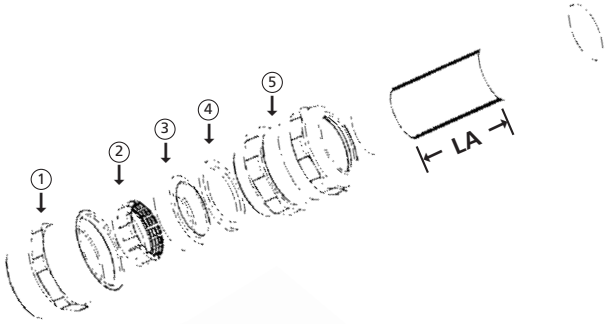
Artikel *Article*	**a/mm** *a/mm*	**Nenndrehmoment/Nm** *Nominal torque/Nm*
bg 212mstri	7	5
bg 216mstri	8	8
bg 220mstri	9	10
bg 225mstri	10	15
bg 232mstri	11	15
bg 240mstri	13	20
bg 250mstri	15	30
bg 263mstri	15	35
bg 275mstri	15	80
bg 285mstri	15	100

Assembly instructions for ID No. 56088 and 56103

blueglobe® AC – Montageanleitung
blueglobe® AC – Assembly Instruction

Übersicht Bestandteile
Overview components

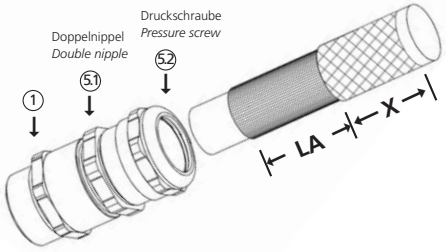
Adapter mit O-Ring ①, Klemmring ②, Druckring ③, Dichtung ④ und Standard - blueglobe® ⑤
Adapter with O-Ring ①, Clamping ring ②, Pressure ring ③, scaling ④, and Standard - blueglobe® ⑤



Schritt 1 – Vorbereitung der Montage
Step 1 – Prepare installation

1. Leitung abmanteln, Armierung kürzen gemäß Tabelle (siehe unten)
1. Dismantle wire, cut armour according table 1 (see below)

2. Adapter ① mit Nenndrehmoment 1 gemäß Tabelle (siehe unten) einschrauben (Komplettverschraubung AC nicht öffnen)
2. Fix adapter ① with torque 1 according table (see below) (do not open complete AC gland)



Schritt 2 – Montage
Step 2 – Installation

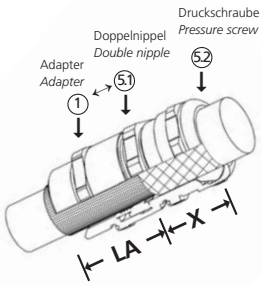
1. Kabel mit Länge X einführen, gemäß Tabelle (siehe unten)
1. Install cable with length X according table (see below)

2. Doppelnippel ⑤.1 mit Nenndrehmoment 1 gemäß Tabelle (siehe unten) anziehen zum Kontaktieren
2. Fix double nipple ⑤.1 with torque according table (see below) for contact

3. Druckschraube ⑤.2 mit Nenndrehmoment 2 gemäß Tabelle (siehe unten) anziehen zur Abdichtung
3. Fix pressure screw ⑤.2 with torque 2 according table (see below) for tightness

Tabelle
Table

Artikel *Article*	**LA/mm** *LA/mm* [min]	**X/mm** *X/mm*	**Drehmoment 1/Nm** *Torque 1/Nm* für/for ① + ⑤.1	**Drehmoment 2/Nm** *Torque 2/Nm* für/for ⑤.2
220bg220msAC13	20	35	15	10
220bg225msAC15	22	37	15	15
225bg225msAC17	22	37	15	15
232bg232msAC23	26	40	25	15
232bg240msAC27	28	43	40	15
240bg240msAC31	28	43	20	20
250bg250msAC36	32	49	50	30
250bg250msAC40	32	49	50	30
263bg263msAC46	32	50	50	35
263bg263msAC51	32	50	50	35
275bg275msAC61	36	62	80	80
285bg285msAC70	38	64	100	100
285bg285msAC78	38	64	100	100



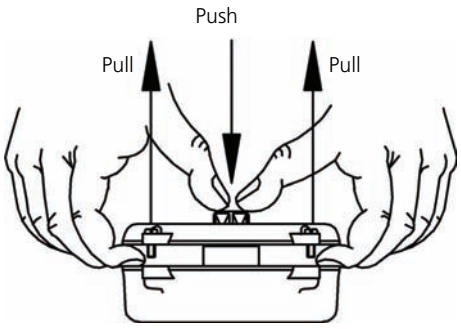
6.2 Limit Switches for Pneumatics

Installation and setup instructions for limit-switch box by KINETROL … -003U Ex ed IIC T6 and … -004U

IMPORTANT

If the limit-switch box … -003U is delivered separately, it has to be stored in a plastic bag until it will be installed.
The certification will keep its validity only if the limit-switch box has been installed correctly on the swivel drive.

For indirect installation, the limit-switch box can be supplied, on customer's request, with installation dimensions according to VDI/VDE 3845 or according to KINETROL's factory norm (see below).



Direct installation

- Unscrew the cover of the supplied limit-switch box and pull it off, as shown in the illustration, while pushing down the limit-switch shaft. Caution: Do not lose the cover sealing!
- Remove shaft mounting bracket by opening the screws and take off the limit-switch shaft.
- Clamp swivel drive in vise (use soft jaws)
- Apply LOCTITE (or a similar adhesive) on mounting thread, put on the supplied cork sealing and attach the bottom part of the limit-switch box. Fix it using the screws supplied.
- The two trip cams on the limit-switch shaft are fixed by one screw each. Untighten these screws.
- Place limit-switch shaft with the Allen key onto the upper four cornered shaft of the drive or the spring lock unit. DO NOT HAMMER – DO NOT APPLY FORCE!
- Install shaft mounting bracket again.

Adjusting the trip cams

- Set revolving wings of the swivel drive to the initial position. Caution: The mechanical end stops of the swivel drive should have been set already to make subsequent correction of the trip cams superfluous.
- Move the respective trip cams on the guide ring until a soft click indicates that the contact of the micro push-button (… -3U) or micro push-button (… -4U) has switched. To be on the safe side, move the trip cams by about 2-3 degrees further and tighten the clamping screw.
- Move revolving wings to the opposite stop position. Compressed air is needed for single-acting swivel drives with spring lock unit.
- Proceed accordingly with the second trip cam.

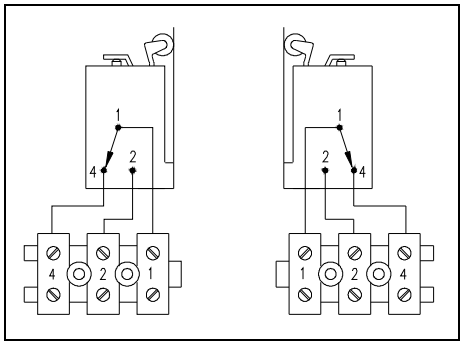
Technical Specification / Electrical Wiring

... **-3U**

2 micro push-buttons

BARTEC 07-1501-6120-63 (closer) for drive size 02/03

BARTEC 07-1501-6130-63 (changer) for drive size 05-14

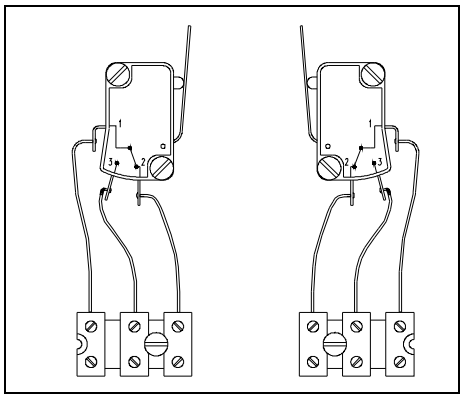


Volt		Load (A)	
AC	DC	Resistor	inductive (max.)
250		7	5
125		7	5
	up to 12	7	5
	up to 24	1	1
	up to 48	0.5	0.06
	up to 250	0.3	0.03

... **-4U**

2 micro push-buttons

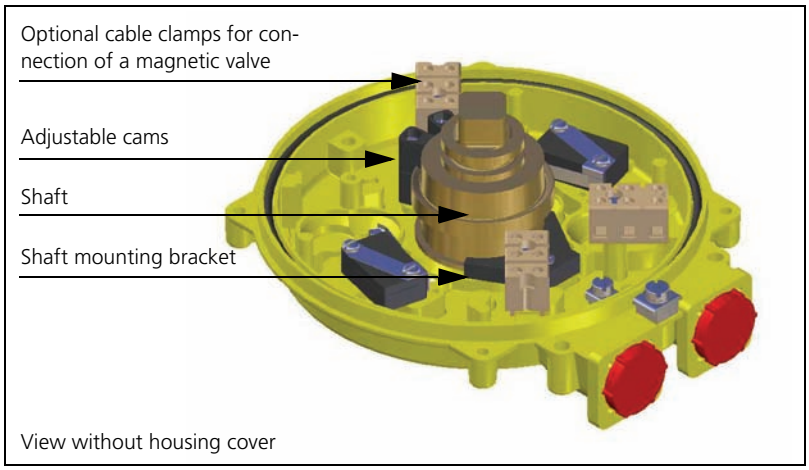
Standard dimensions according to DIN41635



Volt		Load (A)		
AC	DC	Resistor	inductive (max.)	Lamps
250		15	5	1.5
125		15	5	1.5
	up to 12	15	5	1.5
	up to 24	10	1	1
	up to 48	3	0.06	0.3
	up to 250	0.25	0.03	0.025

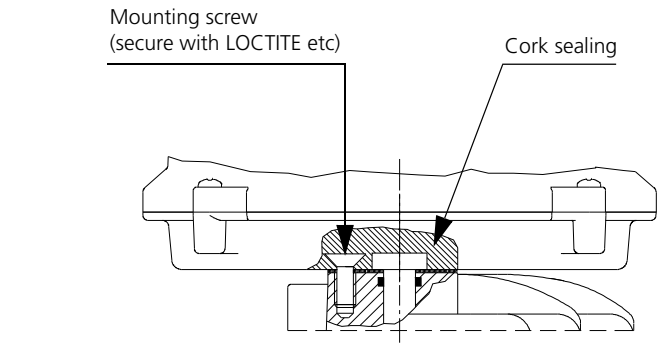
Material: ... **-3U und** ... **-4U**

	KINETROL ...-3U	KINETROL ...-4U
Housing	Zinc die casting	
Coating	Epoxy resin, burned in	
Sealing	O-rings (Nitril)	
Temperature range	-25°C to +60°C	-20°C to +80°C
Weight	1,4 kg	
Cable inputs	M20x1.5	M20x1,5; PG13,5; ½" NPT; 4-pole connector (DIN 43650A)
Cable clamp	Terminal cross-section 2.5 mm², grounded conductor terminal 2.5 mm², earthed conductor clamp 4.0 mm²	
Protection type	IP54–65	

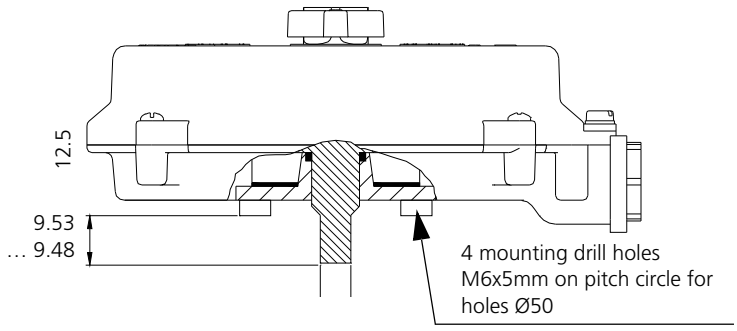


View without housing cover

Technical Specification / Electrical Wiring



Direct installation



Installation according to factory norm

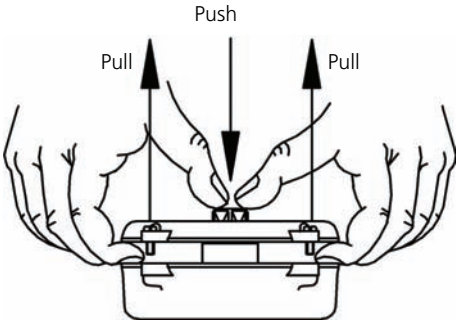
After connecting, tighten the stuffing box fitting.

IMPORTANT

Make sure that the cover sealing is inserted in its groove!

Slightly grease the housing cover in the shaft duct with MoS_2 grease, attach it and tighten cover screws.

Correction of the switching points for drive with pre-assembled limit-switch box



Direct installation

- Unscrew the cover of the supplied limit-switch box and pull it off, as shown in the illustration, while pushing down the limit-switch shaft. Caution: Do not lose the cover sealing!
- Remove shaft mounting bracket by opening the screws and take off the limit-switch shaft.
- Apply LOCTITE (or a similar adhesive) on mounting thread, put on the supplied cork sealing and attach the bottom part of the limit-switch box. Fix it using the screws supplied.
- The two trip cams on the limit-switch shaft are fixed by one screw each. Untighten these screws.

See further steps *"Adjusting the trip cams"* on *page 2-168* and *"Technical Specification / Electrical Wiring"* on *page 2-169*

Notes:

Subject to change in the course of further technical development.

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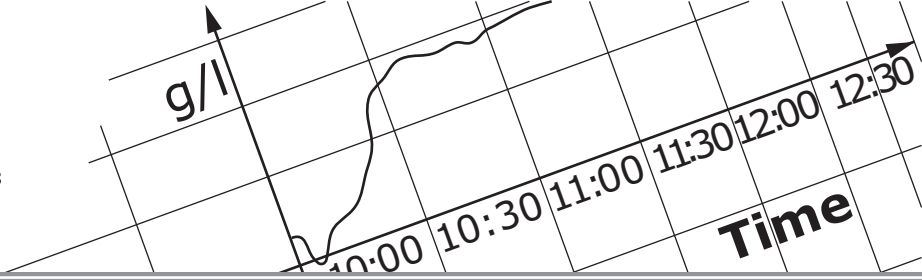


Volume 3 Operation with HART® Communicator

1

HART® Communication

The LB 480 can be operated with the following hosts:

- HART® Communicator (375/475) by Emerson Process
- Siemens Simatic PDM
- AMS DeltaV by Emerson Process

1.1 HART® Protocol

The density measured value is transferred in the process variable PV.

1.2 General Information on the HART® Communicator

IMPORTANT

Changes in the parameters affect the behavior of any connected controller and can lead to undesirable operating conditions. Never change the parameter settings without a full knowledge of this User's Manual as well as a full knowledge of the behavior of the connected controller and the possible influence on the operating process to be controlled.

The measuring system SENSseries LB 480 is compatible with the HART® Communicator Model 375 with firmware 3.0 and the Model 475 (HART® Communicator, HART = Highway Addressable Remote Transducer) by Emerson Process Management GmbH & Co. OHG. Other HART® compatible communicators may also be used, provided they support Enhancements. The HART® Communicator uses the Bell 202 Frequency Shift Keying technique to superimpose high-frequency digital communication signals on the standard 420mA current loop. The minimum load resistance on the 420 mA loop has to be 250 ohms.

Refer to the instruction manual for the HART® Communicator for information on key usage, data entry and equipment interface.

1.3 Connection, Power On and Power Off of the HART® Communicator

Risk of explosion!

In hazardous areas, a HART® Communicator may be connected only under the following conditions:

– the current output of the measuring system SENSseries LB 480 is intrinsically safe

– the HART® Communicator is intrinsically safe

– the HART® Communicator has previously never be connected to non-intrinsically safe live electric cables.

The communicator may be switched on only after it has been connected to the HART® current output. Otherwise, communication with the detector is not established.

For safe HART® communication you need an impedance of at least 250 to maximum 500ohms at the current output.

The Start menu appears as soon as the detector and the Communicator have been connected and commissioned properly (see page *page 3-189*).

From this menu you may directly select the item **Live Display** for online display of the measured values. The measured data are only valid when the probe was calibrated and configured.

The Communicator may be turned off or disconnected only after completion of a possible parameter change of the detector.

1.4 Working with the HART® Communicator

The Communicator is easy to use:

- Use the arrow keys to select a menu item and then press the button with the right arrow key or the ***ENTER*** key. Alternatively, you can press the number listed in front of most menu items on the numeric keypad; then the menu item is called immediately.
- To change information or data, use the softkeys on which the valid function is depicted, e.g. ***SAVE, ABORT, OK, ENTER*** or ***SEND***. Push ***HOME*** to return to the Start menu (see *chapter 2.3, "Start Menu"*, *page 3-189*).
- Use the numeric keypad to enter numbers. With these keys you can also enter text for some menu items by pressing the appropriate number key repeatedly.

1.5 Archiving Parameter Sets

Parameter sets can be archived from the LB 480 to a PC via these hosts:

- HART® Communicator Model 375/475
- Siemens Simatic PDM
- AMS DeltaV, Emerson Process

IMPORTANT

Depending on the HOST system, it may happen that certain parameters are not stored correctly.
Therefore, verify the data stored after each archiving step.
Even if you restore the saved data to the LB 480, you have to check the calibration setting afterwards.

1.5.1 HART® Communicator

The HART® Communicator Model 375/475 allows you to archive parameters sets. For this purpose, the parameter set first has to be saved using the software button **SAVE** from the detector to the SD card of the HART® Communicator. The stored data can then be archived to a PC via SD card or via infrared interface. First, preparatory actions have to be performed in the Online menu. The following sequence shows how the parameter set can be transferred from the detector to a PC via SD card.

1. Enter the file name of the parameter set for archiving in the Tag parameter.

   Command: **Tag**

   Execution:
   Online via the HART® Communicator in the **Identification** menu, select the **Tag** parameter and enter a name. Up to 8 characters.

2. Load current measurement parameters to the calibration parameters.

   Command: **Recall**

   Execution:
   Online via the HART® Communicator in the **Cal Parameter** menu, select the command **Recall**.

3. Save parameter set to the HART® Communicator.

   Command: **SAVE**

   Execution:
   Online via the HART® Communicator, push the software button **SAVE** on the display.

   Info:
   The parameter set is now also available offline on the HART® Communicator.

4. Transfer parameter set to PC.

   You need the program "Easy Upgrade Utility" for this step. This program must be installed earlier on the PC.

   Execution:

   – Remove SD card from 475 and insert it into the SD card reader of your PC.
   – Start Easy Upgrade Utility.

   The following steps describe the sequence in "Easy Upgrade Utility":

   – ("Update PC" recommended)
   – Connection type: Card Reader
   – "Connect"
   – Select "More options ...".
   – Select "HART configuration" tab.
   – Select a file in the right box and upload it to the PC database in the left box.

   The parameter set can now be displayed, or printed, by double-clicking.

   For more information about "Easy Upgrade Utility" please refer to the Online help.

To transfer already archived files to the detector:

1. Transfer the file from PC to SD card using "Easy Upgrade Utility".
2. Insert SD card again in the HART® Communicator.
3. Select the parameter set in the offline mode of the HART® Communicator and transfer it to the detector with the **Send** command.

   The detector is now ready for measurement.

To update the data, you have to restart the HART® Communicator.

For archiving with other hosts please see the following chapter.

1.5.2 PDM (Siemens Simatic PDM)

The PDM can also store data in the offline menu. Again, you have to select **Recall** on the **Cal Parameter** menu.

When restoring the data to the detector, it is necessary to transfer the data twice to the detector. This ensures that the data will be properly enabled in the detector.

1.5.3 AMS (DeltaV Emerson Process)

The AMS can save data in the offline menu only from version 10 and above. Again, you have to select **Recall** on the **Cal Parameter** menu.

However, safe transfer of data from the offline menu to the detector can only be guaranteed by transmitting each parameter individually. You have to check whether the corresponding value has actually been transmitted properly. Then in addition you have to select **Restore** in the **Cal Parameter** menu to transfer the calibration values into the measurement parameters.

2 Menu Structure

2.1 Information on the Menu Structure

The menu structure on the following pages provides an overview over all functions of the SENSseries detectors. Using the page numbers indicated you can look up explanations on the function of each menu item.

First *ENTER* then *SEND*

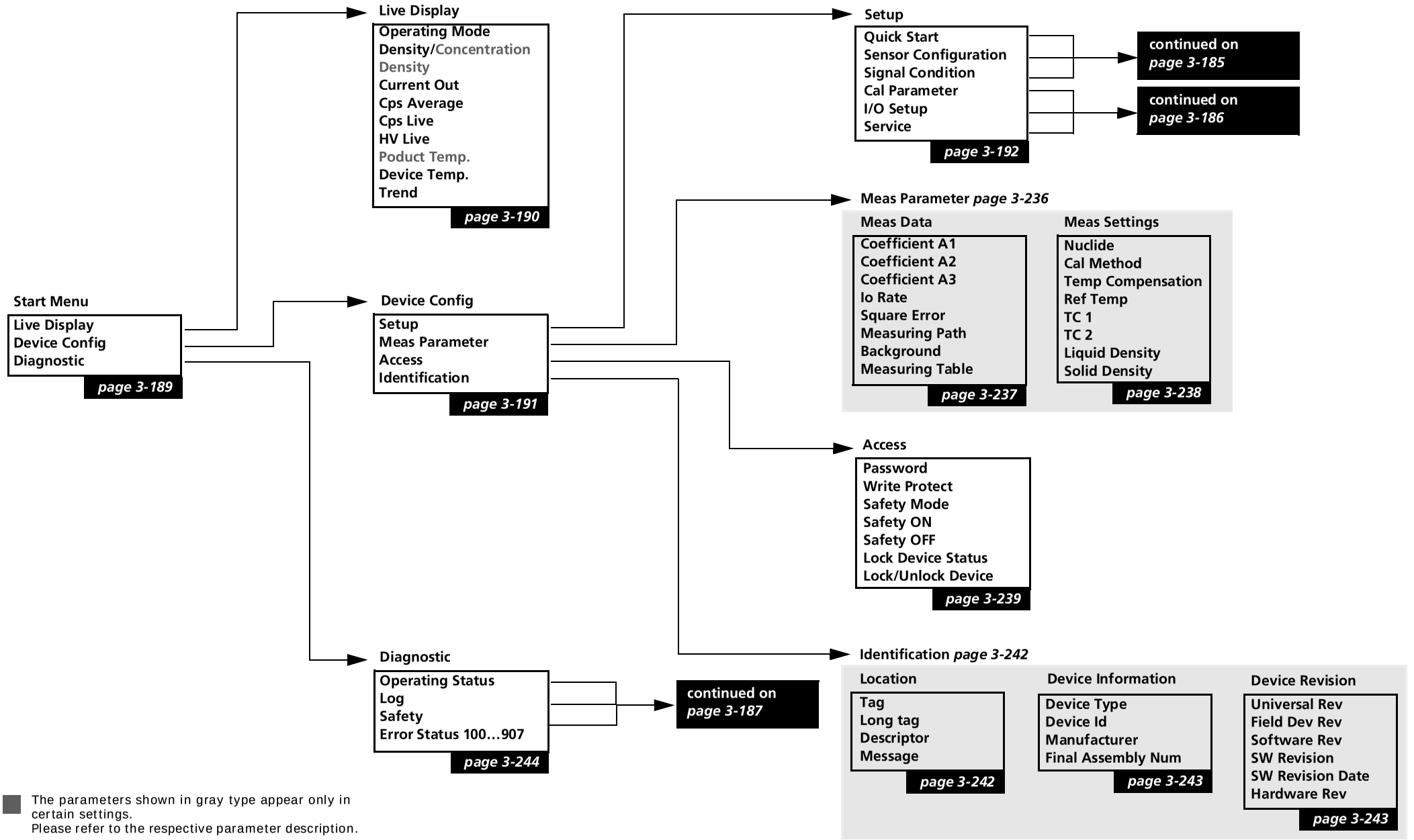
To rule out incorrect entries, you always have to push the ***SEND*** softkey immediately after you have entered a value via the ***ENTER*** button. The ***SEND*** softkey is only visible after values have been changed.

- Push ***ENTER*** to save edited values and parameters in the Communicator.
- Push ***SEND*** to transfer all modified values from the Communicator to the detector.

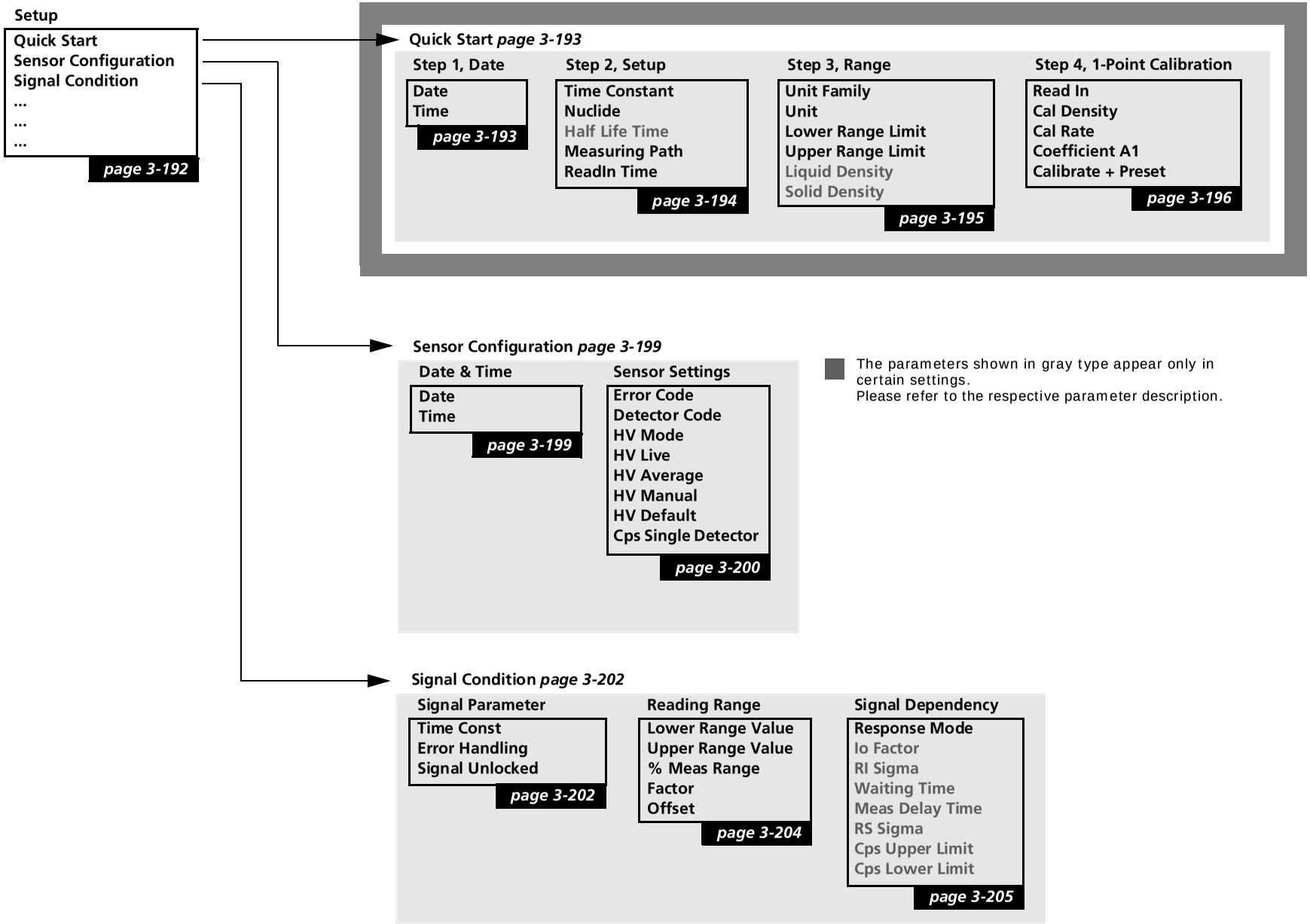
The following sections assume that you:

- know how to work with the Communicator
- have read and understood *Volume 2* of this User's Manual.

2.2 Menu Overview



The parameters shown in gray type appear only in certain settings.
Please refer to the respective parameter description.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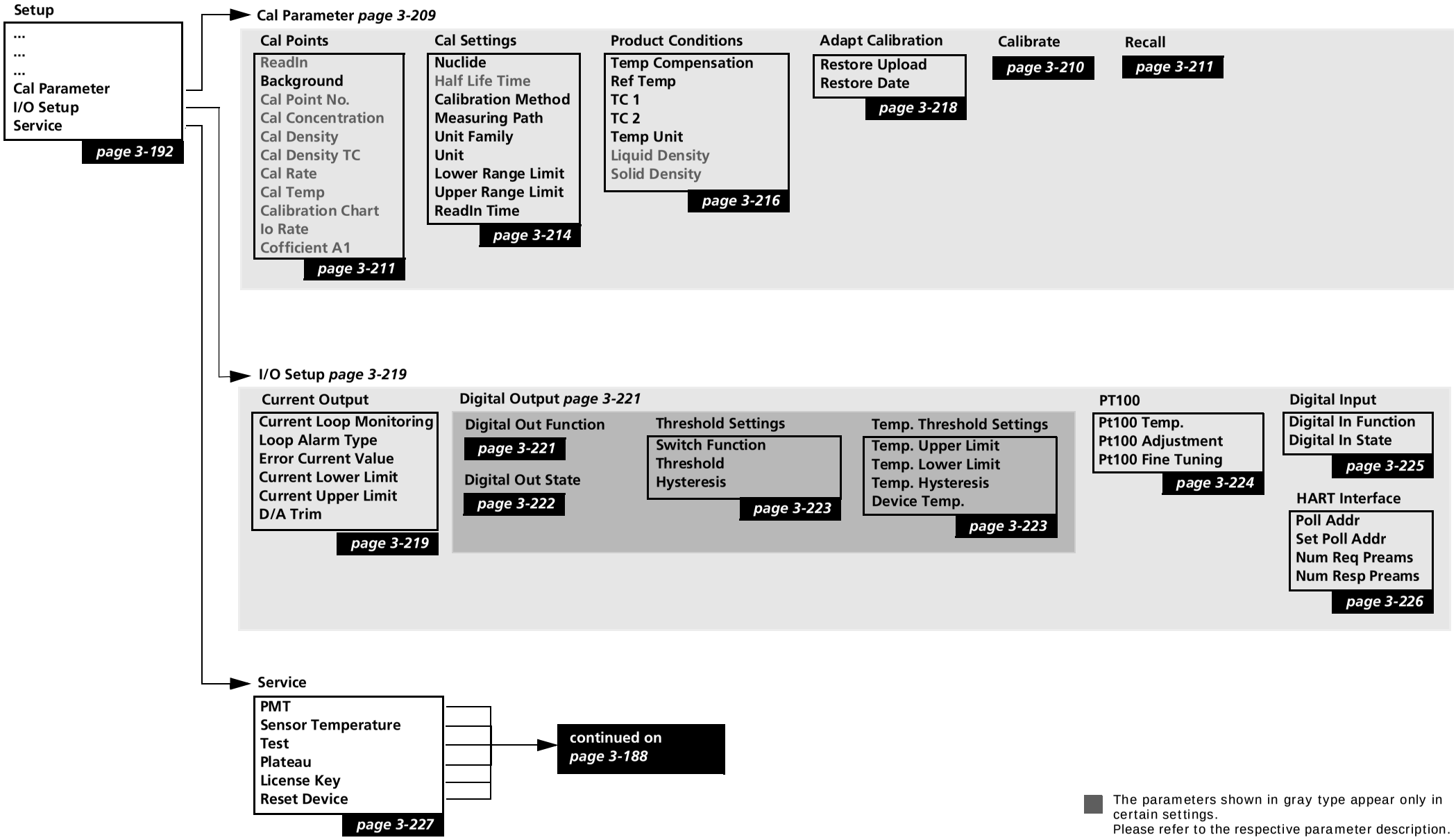
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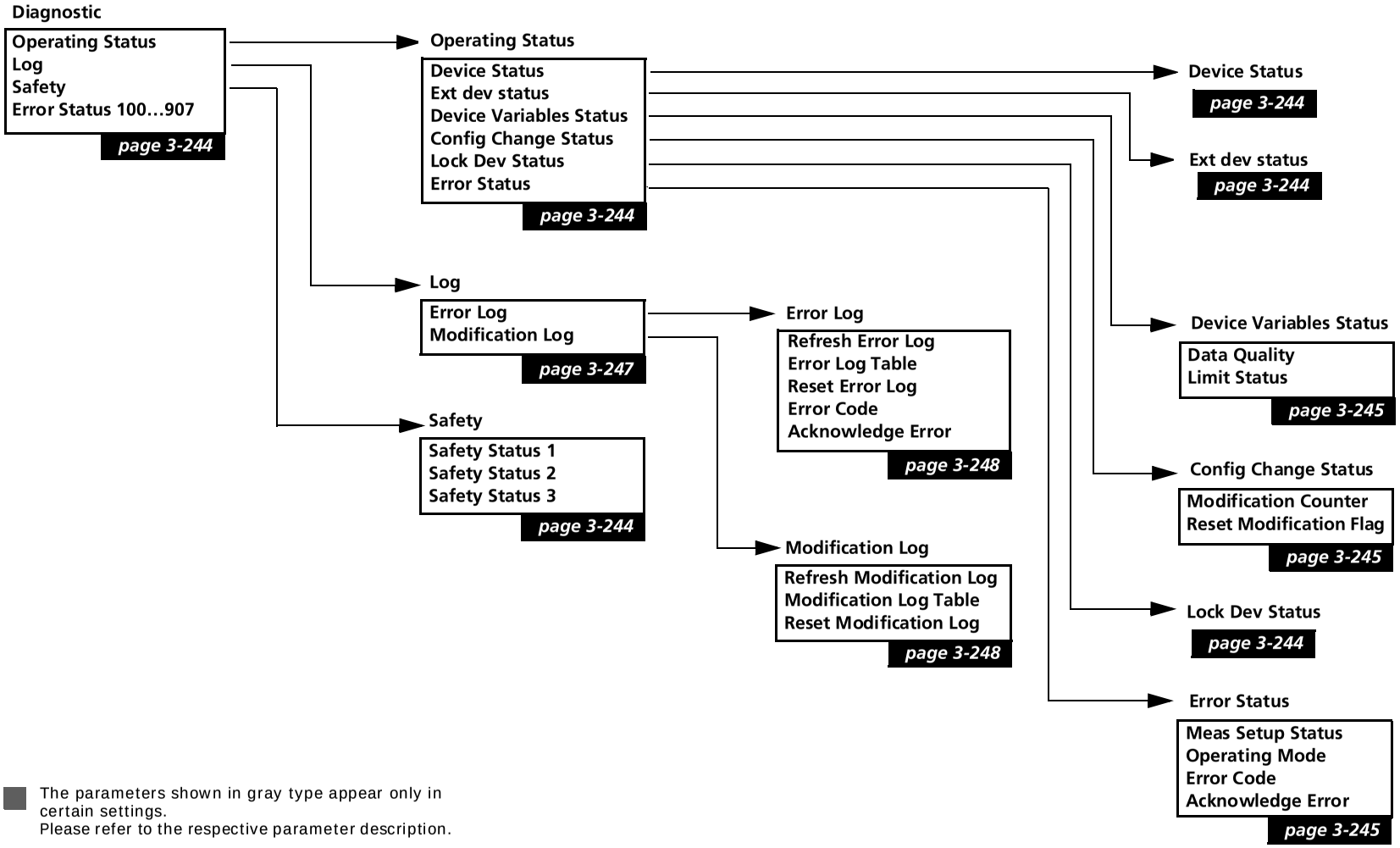
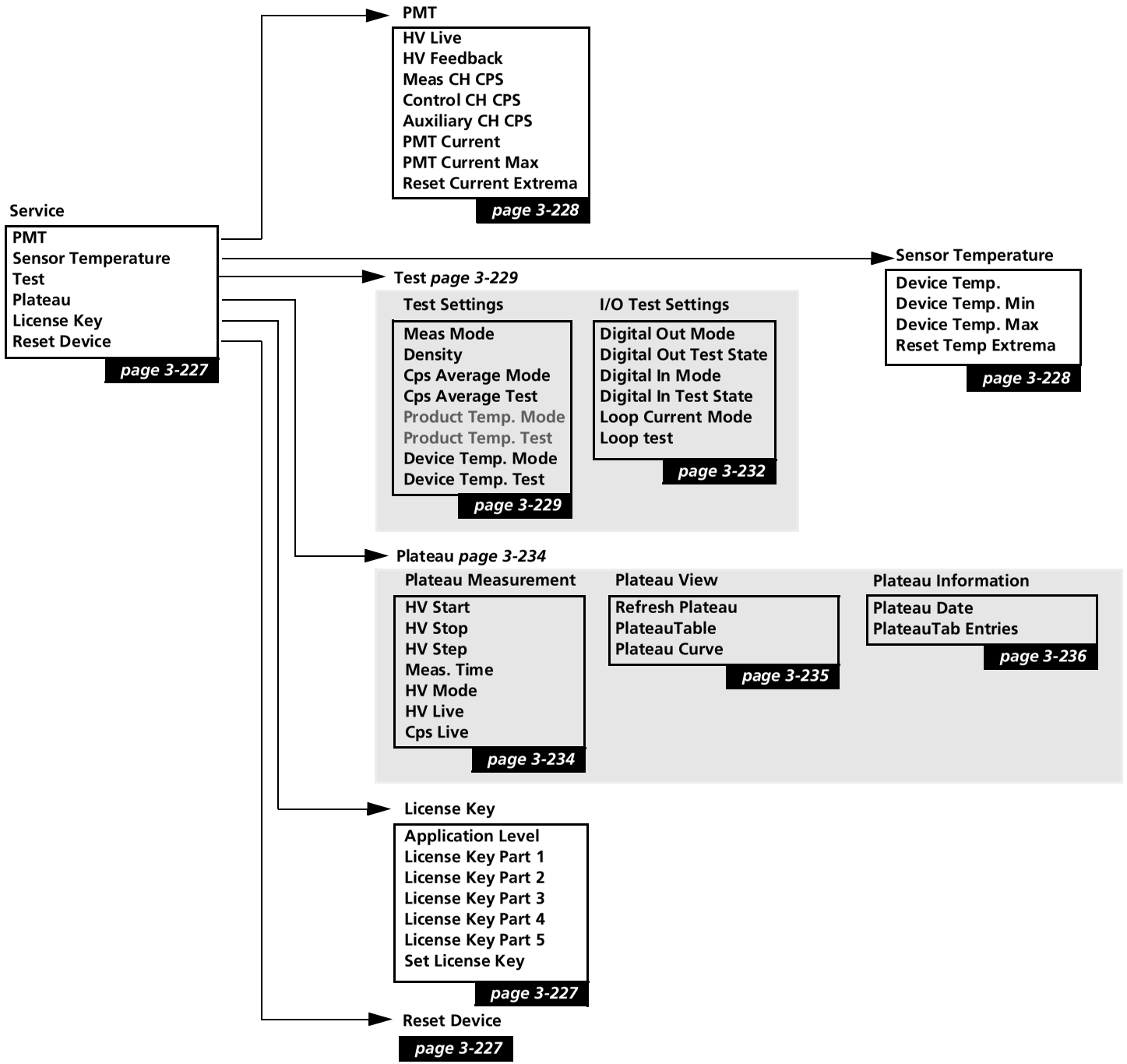
The parameters shown in gray type appear only in certain settings.
Please refer to the respective parameter description.



The parameters shown in gray type appear only in certain settings.
Please refer to the respective parameter description.



The parameters shown in gray type appear only in certain settings.
Please refer to the respective parameter description.

2.3 Start Menu

The Start menu is the first and highest level for communication with the SENSseries. From the Start menu you have access to all other menu items.

The Start menu appears if you...

- switch on the connected HART® Communicator or
- push the ***HOME*** softkey anywhere in the menu.

1 Live Display

Shows the menu with the currently measured values (*page 3-190*).

2 Device Config

Leads to the menu for setting the detector parameters (*page 3-191*).

3 Diagnostic

Opens the menu displaying status and error information and the protocols for errors and parameter changes (*page 3-244*).

2.4 Live Display

1 Operating Mode

Shows the current operating status.

The following states may occur:

- ***RUN***

  The measurement is in the normal measurement mode.

- ***WARNING***

  An error category **2** warning is displayed.

  If the error is no longer displayed in **Active Error**, you can view it in the error log (**Diagnostic ▶ Log**, *page 3-247*). In *chapter 8* on *page 3-307* you find a list of possible causes and troubleshooting procedures.

- ***ERROR***

  An error category **1** error is displayed.

  If the error is no longer displayed in **Active Error**, you can view it in the error log (**Diagnostic ▶ Log**, *page 3-247*). In *chapter 8* on *page 3-307* you find a list of possible causes and troubleshooting procedures.

- ***SHUTDOWN***

  A serious error category **0** error is displayed.

  If the error is no longer displayed in **Active Error**, you can view it in the error log (**Diagnostic ▶ Log**, *page 3-247*).

  In *chapter 8* on *page 3-307* you find a list of possible causes and troubleshooting procedures. If the error does not disappear after restart (power off and then on, or software reset, *page 3-227*), then the detector must be replaced.

- ***HOLD***

  The measurement is in the hold state, which means that the measured value and the current output signal is frozen. This status can occur under the following conditions:

  – the plateau recording is running
  – interference radiation was detected
  – the digital input is on Hold

- ***TEST***

  A test value is enabled, see *chapter 2.36*, *page 3-229*.

2 Density / Concentration

Displays the current measured value.

3 Density

Displays the current density. The parameter is displayed only if the calibration was performed as a suspension measurement.

4 Current Out

Displays the actual output current at the analog output in mA.

5 Cps Average Shows the current count rate averaged over the time constant.

6 Cps Live Shows the current non-averaged count rate.

7 HV Live Displays the current HV (high voltage) at the photomultiplier. If **HV Mode** is set to ***AUTO*** (normal operation), the values in **HV Live** must change, viewed over several seconds.

8 Product Temp. ◇ Visible only with temperature compensation enabled.

Shows the product temperature, for example, the liquid temperature in the tube, the density of which is to be measured.

9 Device Temp. Displays the temperature inside the detector.

10 Trend Displays the trend of important measured values such as density, count rate and temperature.

2.5 Device Config

1 Setup Opens the Setup menu. If ***Setup !locked!*** appears here, then the access has to be enabled via **Access** (*page 3-192*).

2 Meas Parameter Leads to the menu displaying the currently valid measurement parameters that are used to determine the measured value (*page 3-236*).

Each calibration with **Calibrate** overwrites these values again. These readings help the user to check his calibration.

3 Access Opens the menu for entering the password, the options to prevent configuration changes and to activate the safety mode (*page 3-239*).

4 Identification Opens the menu displaying various detector parameters, such as model, device ID, software and hardware revision (*page 3-242*).

2.6 Setup

Menu path: **Device Config ▶ Setup**.

These menus allow you to make changes to the settings and the calibration of the detector. Upon delivery of the instrument, access to all menu items is possible without password. If a password has been entered and activated, you must enter it again to allow access (see *chapter 2.45*, *page 3-239*).

Use **Recall** (**Device Config ▶ Setup ▶ Cal Parameter ▶ Recall**, *page 3-209*) if you only want to change a few settings. This will copy the current settings in the menus for the setup and you can make changes to individual settings.

Enable the changes with **Calibrate** (**Device Config ▶ Setup ▶ Cal Parameter ▶ Calibrate**), see *chapter 2.19*, *page 3-209*.

1 Quick Start

Opens a menu that enables fast user-guided, initial configuration of the detector (*page 3-193*).

2 Sensor Configuration

Opens the menu for the sensor settings (*page 3-199*).

3 Signal Condition

Opens the menu for the signal processing settings (*page 3-202*).

4 Cal Parameter

Opens the menu for the calibration (*page 3-209*).

5 I/O Setup

Opens the menu for the I/O functions (*page 3-219*).

6 Service

Opens the menu for testing and service functions as well as for the plateau measurement and display of the plateau values (*page 3-227*).

2.7 Quick Start

Menu path: **Device Config ▶ Setup ▶ QuickStart**.

QuickStart allows you to quickly take the detector into operation, without having to deal with the complete menu. Additional functions can be enabled any time on the main menu.

IMPORTANT
*Changes in the **Quick Start** menu must finally be enabled with **Calibrate + Preset** (in Step 4).*

2.8 Quick Start, Step 1: Date

Enter the current date and time.

The correct date is important for the automatic decay compensation of the isotope. Since the activity of the source diminishes with time, the calibration count rates will be compensated automatically through the date. The decay compensation takes place daily at 09:01 h

1 Date

Current date. The date is specified in the following format:

- MM/DD/YYYY.

If the detector detects that the date deviates, a date error is indicated.

The response of the signal output depends on the setting in **Error Handling** (**Device Config ▶ Setup ▶ Signal Condition ▶ Signal Parameter**, *page 3-202*):

- ***NORMAL***

  The measurement continues with the last saved date.

- ***SENSITIVE***

  The measurement goes to the safe condition and the current output goes to fault current.

2 Time

Current time. The time is specified in the following format:

- hh:mm:ss

Differences in time have virtually no effect on the correction of the decrease in activity. However, the correct time is helpful to check the detector function: If an error occurs, you can see in the error log (**Diagnostic ▶ Log**, *page 3-247*) when exactly the error occurred.

2.9 Quick Start, Step 2: Setup

1 Time Constant

The time constant smoothes the output signal. Essentially, statistical fluctuations will be smoothed. A time constant of 30 s to 60 s is usually reasonable.

2 Nuclide

▶ Enter here the isotope (nuclide) that is used in your source:

- ***Co-60***
- ***Cs-137***
- ***USER DEFINED***

This entry controls the automatic decay compensation. The correct entry is also important in a one-point calibration and for gas density compensation. The isotope used is listed on the type plate of the shielding and on your delivery documents. The item ***USER DEFINED*** allows you to use any isotope you want. In this case, the parameter **Half Life Time** is queried in addition.

What happens when you have selected the wrong isotope?

As a result of the wrong decay compensation, you will get a deviating display only after several weeks or months, with the deviation increasing over time.

3 Half Life Time

◇ Visible only if **Compensation Mode** is set to ***MANUAL GDA***.

Required only for special applications.

Enter the half-life in years.

4 Measuring Path

Enter the measuring path of the beam path through the product to be measured.

Generally it corresponds to the inner diameter of the pipe. Especially with the one-point calibration, you must enter this value exactly to the millimeter.

5 ReadIn Time

Define here the period of time over which the count rate is to be read-in with **ReadIn** for each calibration point.

The statistical variation of the count rate is averaged over this time period. The longer it is, the better the mean value. A time period of 30 s (default setting) is usually reasonable.

2.10 Quick Start, Step 3: Range

Define the measuring range and the unit of measurement.

1 Unit Family

Select the unit family for the measurement. Depending on this entry, the relevant units are available for selection under **Unit**, such as:

- ***DENSITY*** (g/cm³, kg/m³, g/l, ...)
- ***LENGTH*** (m, mm, yard, ...)
- ***SUSPENSION*** (%sol-wt, g/l, °Be)

Please note: When selecting ***SUSPENSION***, the measurement operates in a mode in which the concentration level of a substance is measured, for example, the proportion of the solid in a carrier liquid (%sol-wt). Additional inputs for **Liquid Density** and **Solid Density** are required.

*Information on **SUSPENSION** (suspension measurement):*

Since the concentration is not proportional to the density, the concentration is internally converted into g/cm^3. This conversion allows a linear calibration curve and with a one-point calibration the use of the standard coefficients for A1. To convert concentration values ??into g/cm^3, the entries for **Liquid Density** and **Solid Density** are required.

2 Unit

Select the unit in which the measured value is to be displayed. To select units that are not included in the list, you may need to change the **Unit Family**.

3 Lower Range Limit

Enter the lower limit of the measuring range where 4 mA is to be output.

4 Upper Range Limit

Enter the upper limit of the measuring range where 20 mA is to be output.

5 Liquid Density

◇ Required only if ***SUSPENSION*** was selected.

Enter the density of the carrier liquid in g/cm^3. In water, for example 1.00g/cm^3. For solutions, you have to enter the density of the main component.

6 Solid Density

◇ Required only if ***SUSPENSION*** was selected.

Enter the density of the carrier liquid in g/cm^3. For solutions, you have to enter the density of the main component.

Enter the density (g/cm^3) of the solid, and for solutions the density of the second component.

Example with sand as a solid:

With sand, the value to be entered corresponds to the average density of each individual grain of sand. This value is approximately 2.65g/cm^3.

2.11 Quick Start, Step 4: 1-Point Calibration

This menu allows you to determine the calibration date and then calibrate the instrument. When you calibrate, these data are transferred to the **Measurement Data** menu and thus activated for the measurement.

1 Read In

Start reading-in the count rates. While the count rate is read in, the average is calculated and displayed continuously.

The read-in period is defined under **ReadIn Time** *(chapter 2.9, "Quick Start,* Step 2: Setup"*, page 3-194)*.

Enter the averaged count rate in **Cal Rate**.

When reading-in the count rates, the time remaining up to the end of the operation is displayed. Finally, you are prompted to confirm the measured count rate with ***OK***. To shorten the read-in process, you can stop any time by pressing ***OK***.

2 Cal Density

Density for the calibration point.

Enter the density or concentration of the analyzed sample value.

3 Cal Rate

Count rate for the calibration point.

Select ReadIn to read in the count rate. If you already know the value, you can enter it here.

When reading in the count rate, you have to take the lab sample at the same time, or at least within a narrow time frame.

4 Coefficient A1

Absorption coefficient.

Determines the slope and thus the sensitivity of the measurement.

For the following units, the standard value -0.066 can be entered, provided Cs-137 is used as a radiation source:

– g/cm^3 (density) also for all other "density units"

– Wt% (concentration)

– g/l (concentration)

– °Be (concentration)

– °Bx (concentration)

If Co-60 is used as a radiation sources, then enter -0.048.

Other units, e.g. the length or volume units, require a multi-point calibration, which is only possible in the Cal Parameter menu.

The absorption coefficient can be entered in two different ways.

Example with input value -0.066:

- -0.066
- -66e-3

Entering the value as a power of ten allows you to enter very small coefficients without any problems.

5 Calibrate + Preset

With this menu item you enable the calibration data determined during the measurements. The calibration data are transferred to the parameter set Meas Parameter. Thus, the detector will get a new calibration which in the future will be used to determine the measured values.

After the calibration, a status message is displayed, indicating if the activation of the calibration data has been carried out successfully. If not, the measurement parameters are unchanged. Possible status messages are:

- ***0-OK***: The calibration carried out is OK.
- ***1-ERROR BACKGROUND***:
  The count rate of the background radiation is higher than that for the calibration points for empty or full (Cal Point 0% or Cal Point 100%).
- ***2-MISSING CALIBRATION POINT***:
  The number of calibration points is not sufficient. Depending on the calibration type, at least the following number of calibration points is required:
  - ***DIRECT ENTRY***: none
  - ***1-POINT***: one
  - ***LINEAR***: two
  - ***SQUARE***: three
  - ***CUBIC***: four
- ***3-ERROR NOT MONOTONOUS***:
  The calibration curve is not monotonous, i.e. two different readings can be interpreted for the same count rate.

◇ Appears only with calibration type ***SQUARE*** and ***CUBIC***.

Calibration curve must be visually inspected and qualified. Restricting the measuring range may be helpful.

- ***4-DATE ERROR***:
  A date is still set to the default value of 1.1.2000. At **Calibrate**, check the **Date** parameter. At **Restore**, check the date in **Restore Date**.
- ***5-CHECK ERROR***:
  The status of the calibration parameters could not be fully verified. In this case, repeat the calibration. If the error occurs again, replace the detector, at least the detector electronics.

The following settings are made automatically at **Calibrate** + **Preset**:

- **Temp Comp** = ***OFF***
- **Calibration Method** = ***1-Point***
- **Background** = ***0***
- **Factor = 1**
- **Offset = 0**

2.12 Sensor Configuration

Menu path: **Device Config ▶ Setup ▶ Sensor Configuration**.

The **Sensor Settings** are preset at the factory.

1 Date & Time

Opens the menu for the date and time (*page 3-199*).

2 Sensor Settings

Opens the menu for the detector code and HV settings (*page 3-200*).

2.13 Date & Time

Menu path: **Device Config ▶ Setup ▶ Sensor Configuration ▶ Date & Time**.

The correct date is important for the automatic decay compensation of the isotope. Since the activity of the source diminishes with time, the calibration count rates will be compensated automatically in the **Meas Data** menu through the date. The decay compensation takes place daily at 09:01 h. A capacitor ensures that the date and time continue to run for about a month even when the detector is turned off and even if the power supply is switched off. If the detector has not been supplied with power for a longer period of time (several weeks), then the capacitor may be empty. If the power supply is switched on again, then the clock starts with the last saved date and an error message "Real time clock not valid" indicates that the date must be updated.

1 Date

Current date. The date is specified in the following format:

- MM/DD/YYYY.

If the detector detects that the date deviates, a date error is indicated. The response of the signal output depends on the setting in **Error Handling** (**Device Config ▶ Setup ▶ Signal Condition ▶ Signal Parameter**, *page 3-202*):

- ***NORMAL***

  The measurement continues with the last saved date.

- ***SENSITIVE***

  The measurement goes to the safe condition and the current output goes to fault current.

2 Time

Current time. The time is specified in the following format:

- hh:mm:ss

Differences in time have virtually no effect on the correction of the decrease in activity. However, the correct time is helpful to check the detector function: If an error occurs, you can see in the error log (**Diagnostic ▶ Log**, *page 3-247*) when exactly the error occurred.

2.14 Sensor Settings

Menu path: **Device Config ▶ Setup ▶ Sensor Configuration ▶ Sensor Settings**.

1 Error Code

Indicates if an error is present in the active detector.

If no error is present, then ***0*** is displayed here.

An error message is displayed with a three digit number. The cause of the error and suggestions for correcting the error are described in *chapter 8*, *Error Handling*.

2 Detector Code

The currently selected detector code is displayed.

The detector code is crucial for the proper function of the automatic HV control (high voltage control).

- Point detector NaI 50/50 = ***0***
- SuperSENS 150/150 = ***23***

3 HV Mode

The HV-mode (high-voltage control) provides the following options:

- ***AUTO***

  Automatic HV control. Select this mode in normal measurement mode. It enables a temperature-stable operation of the detector.

- ***MANUAL***

  Manual HV control. This setting is used for testing purposes; you can also provisionally set the operating point of the detector. The specified voltage must, however, lie in the plateau.

  If you select ***Manual***, the automatic HV control is switched off. The HV is then set to the value that was set in the menu item **HV Manual** (6).

- ***PLATEAU***

  Starts the plateau measurement. If you select ***PLATEAU***, the measurement mode is exited and the plateau of the multiplier measured, which is used in the detector. The plateau is measured using the settings in the menu **Device Config ▶ Setup ▶ Service ▶ Plateau**.

  At the end of the plateau measurement the detector automatically switches back to **HV Mode**: ***AUTO*** or ***MANUAL***, depending on which mode was last set.

4 HV Live

Displays the current HV (high voltage) at the photomultiplier. If **HV Mode** is set to ***AUTO*** (normal operation), the values in **HV Live** must change, viewed over several seconds.

5 HV Average

Shows the average HV (high voltage) of the last 10 days.

Significant deviations from **HV Live** to **HV Average** are considered and reported as errors.

If you change **HV Default**, **HV Average** automatically takes over the value from **HV Default**.

6 HV Manual

You can enter a fixed HV value. The value becomes active when you select ***MANUAL*** at **HV-Mode**.

7 HV Default

HV Default causes:

– A quick operation point control after power failure

  After a power failure, the HV starts at the last **HV Average** value which results from the **HV Default**. This will significantly reduce the start-up phase after power failure.

– Error detection in case of HV-drift

  If the HV deviates too far (+40%, -20%) from the HV Default or if the HV reaches the limits of the range of 300 V or 1300 V, this is reported as an error.

– Special feature: 0V

  For maintenance purposes, the **HV Default** can be set to 0V. In this case, the mechanisms described above are suspended; after a power failure, the measurement begins to get adjusted at 800 V.

HV Default has already been determined and set by BERTHOLD TECHNOLOGIES. If this value deviates during the *first commissioning* by more than 5% from **HV Live**, then you have to adjust **HV Default** new.

▶ Set **HV Default** to 0.

▶ Read off the value in **HV Live** 30 minutes later.

▶ Enter the value read in **HV Default**.

With the CrystalSENS, please note that the count rate during this process is above 300 cps to allow the HV to adjust itself.

Tip

The operating point in new detectors is usually between 400 to 900 V. If you get a different value, please contact BERTHOLD TECHNOLOGIES or your local representative.

8 Cps Single Detector

Shows the count rate of the active detector normalized to one second.

2.15 Signal Condition

Menu path: **Device Config ▶ Setup ▶ Signal Condition**.

This menu contains some special features which have a direct impact on the signals of the measurement:

– the way of signaling

– general warning and error messages

– special warning signs for early detection of functional limitations

An important issue are the settings in the menu item **Error Handling** in the **Signal Parameter** menu.

1 Signal Parameter

Opens the menu for error handling and the signal output settings (see below).

2 Reading Range

The measuring range can be specified in this menu.

3 Signal Dependency

Opens the menu in which the interference radiation detection or the rapid switchover can be enabled.

2.16 Signal Parameter

Menu path: **Device Config ▶ Setup ▶ Signal Condition ▶ Signal Parameter**.

1 Time Constant

The time constant smoothes the output signal. Statistical fluctuations and density fluctuations due to the process can be smoothed. A time constant of 30 s to 60 s is usually reasonable.

2 Error Handling

Here you can set a different weighting of errors and error handling:

- ***SENSITIVE***

  All faults cause the current output to report a *Fault current*. To also get warning messages, you must also evaluate the messages via the HART® signal or the digital output.

  The setting ***SENSITIVE*** is automatically enabled when the **Safety Mode** is selected.

- ***NORMAL***

  Only fatal errors are reported as a fault current. Thus, the measured value via the current signal will fail only if the measurement can no longer be used.

  To also get minor error and warning messages, you must also evaluate the messages via the HART® signal or the digital output.

IMPORTANT

*You may select the **NORMAL** setting only if hazards to persons or damage to property a as a result of a faulty measured value can be ruled out.*

Select ***SENSITIVE*** if system safety is an important issue. Use ***NORMAL*** if a failure of the measurement is non-critical for human health and the environment and production safety is an important issue.

To use the digital output for the above mentioned messages, you need to use the setting ***WARNING + ERROR*** in the menu **Digital Out Function** (**Device Config ▶ Setup ▶ I/O Setup ▶ Digital Output ▶ Digital Out Function**, *page 3-221*).

Tip

Error handling is described in detail in *chapter 8* starting on *page 3-307*.

3 Signal Unlocked

You will get alerted when the device is unlocked with a password. The warning message 901 is output. Choose ***WARNING*** only if the control system is to be alerted when the device was unlocked with the password.

- ***OFF***

  The function is switched off.

- ***WARNING***

  Once the detector is unlocked with a password, a warning is issued. If **Error Handling** is set to ***SENSITIVE***, then a fault current is output in addition to the alarm.

The reaction can be identified based on the list in *chapter 8.2* on *page 3-308*.

2.17 Reading Range

Menu path: **Device Config ▶ Setup ▶ Signal Condition ▶ Reading Range**.

1 Lower Range Value

Allows you to change the measuring range even after the calibration.

For the calibration characteristics ***SQUARE*** and ***CUBIC*** which are used in special cases, the measuring range must be set only in the **Calibrate** menu, since there a check regarding the monotony of the calibration measurement is carried out.

2 Upper Range Value

Allows you to change the measuring range even after the calibration.

For the calibration characteristics ***SQUARE*** and ***CUBIC*** which are used in special cases, the measuring range must be set only in the **Calibrate** menu, since there a check regarding the monotony of the calibration measurement is carried out.

3 % Meas Range

Displays the current percentage value within the measuring range. It depends on the current measured value value and the measuring range.

4 Factor

Factor with which the measured value is multiplied. Deviations in the calibration can be corrected with this factor. This allows you to adapt the system to changing operating conditions, such as build up of crusts or abrasion on the pipe wall, without having to carry out a recalibration.

The default value is ***1***.

The Offset and Factor corrected reading is calculated as follows:

Display = measured value x factor + offset

IMPORTANT
Changes have a direct effect on the measured value.

5 Offset

With this function you can adjust the calibration curve by entering an offset (parallel shift of the calibration curve). This allows you to adapt the system to changing operating conditions, such as build up of crusts or abrasion on the pipe wall, without having to carry out a recalibration.

The default value is ***0***.

The Offset and Factor corrected reading is calculated as follows:

Display = measured value x factor + offset

IMPORTANT
Changes have a direct effect on the measured value.

2.18 Signal Dependency

Menu path: **Device Config ▶ Setup ▶ Signal Condition ▶ Signal Dependency**.

On this menu you can enable one of the following functions:

- **RAD. INTERFERENCE**
- **RAPID SWITCH**
- **PULSE LIMIT**

Additional parameters are displayed, depending on which function you select.

1 Response Mode

Select the detection mode:

- ***DISABLED***

  Interference radiation detection, rapid switchover and count rate limits are disabled.

- ***RAD. INTERFERENCE***

  Interference radiation detection is enabled.

  Use this function, for example, to detect external radiation from weld inspections, or short-term use of other sources in the vicinity of the detector.

  Function description:

  If the current count rate exceeds the threshold set in **Io Factor** or in **RI Sigma**, the interference radiation warning will be issued. In this case:

  – the measured value is frozen and

  – the current output holds the last measured value

  The measurement remains frozen as long as the external radiation is present, plus the waiting time that has been set in **Waiting Time**.

  To get the warning messages, you have to evaluate the messages via the HART® signal or the digital output.

IMPORTANT

If interference radiation detection is enabled, the measured values are output with a delay. The delay is adjustable from 0 ... 5 seconds. The delay is required so that at the moment of detection the measured value remains unaffected, even though in this case, increased count rates are already present. For this reason, while interference radiation detection is active, no applications can be run where the reaction time must be below the set delay.

For detailed information please refer to the section Interference Radiation Detection (*chapter 7.2, page 3-288*).

If the source is closed often, or even regularly, then you should keep in mind that in such cases the measurement takes a longer time to return the measured value, because the sigma detection responds when the source is opened. The longer the time selected in **Waiting Time**, the longer the warm-up time.

- ***RAPID SWITCH***

  Rapid switchover is enabled.

  We recommend using the function ***RAPID SWITCH*** only for special applications where the output signal has to adapt rapidly to the new value, e.g. if sudden, strong changes in product density occur.

IMPORTANT
*The function **RAPID SWITCH** should not be enabled when the measurement is installed into a control loop, since this function operates with two different time constants.*

- ***PULSE LIMIT***

  Use this setting if the measurement is to start again without delay with the following conditions:

  – with the pipe running empty
  – with closed source shielding

  By entering count rate limits, the measurement can be stopped automatically and frozen until the count rate is back to normal. The measurement is therefore automatically stopped in the above situations until the pipeline is filled again, and the source shielding is open.

2 Io Factor

◇ Displayed only when **Response Mode** = ***RAD INTERFERENCE***.

Io Factor defines the threshold where the interference radiation detection responds.

With the default value of 1.5, the threshold is 1.5 times the count rate obtained at the lower measuring range limit.

If the current count rate exceeds the threshold set in **Io Factor**, the interference radiation warning will be output. In this case:

– the measured value is frozen and
– the current output holds the last measured value

The factor for the threshold can be chosen as needed. Increasing the factor decreases the sensitivity. Factor ***1.5*** is suitable for most applications.

3 RI Sigma

◇ Displayed only when **Response Mode** = ***RAD INTERFERENCE***.

RI Sigma must be set correctly to detect changes caused by interference radiation within the measuring range. This value is the threshold where the interference radiation detection responds if a sudden increase in radiation occurs. The default value of ***10*** is suitable for most applications. The response becomes less sensitive if you increase the value. To turn the Sigma function off, you can enter the number ***0***.

4 Waiting Time

◇ Displayed only when **Response Mode** = ***RAD INTERFERENCE***.

If interference radiation radiation is detected, the measurement is "frozen" and will be released at the earliest after the waiting period is over. The value must be entered in seconds and should be at least 3 times the time constant. If it is smaller and interference radiation is detected in quick succession, then it may happen that the interference radiation detection does not respond the second time, or only delayed.

To get the warning messages for "Radiation Interference", you have to evaluate the messages via the HART® signal or the digital output.

5 Meas Delay Time

◇ Displayed only when **Response Mode** = ***RAD INTERFERENCE***.

If interference radiation detection is enabled, the measured values are output with a delay. **Meas Delay Time** is adjustable from 0 to 5 seconds.

The delay is required so that at the moment of detection the measured value remains unaffected, because in this case, increased count rates are already present which may distort the measured value. For this reason, while interference radiation detection is active, no applications can be run where the reaction time must be below the set delay.

6 RS Sigma

◇ Displayed only when **Response Mode** = ***RAPID SWITCH***.

This value is the threshold where the rapid switchover responds. The higher the value, the higher the threshold and the less likely the response to interference radiation.

The default value of ***10*** is suitable for most applications.

The response becomes less sensitive if you increase the value.

7 Cps Upper Limit

◇ Displayed only when **Response Mode** = ***PULSE RATE LIMITS*** .

Use this function for example to freeze the measured value when the pipeline is running empty. If the pipeline fills up again, then the time until the measured value becomes stable again is reduced.

Enter a value greater than zero to enable the upper count rate threshold. If the current count rate threshold exceeds the upper threshold, the measurement will be stopped until the measured value has fallen below the count rate threshold again. When the measurement is stopped, the measured value and the current output are "frozen".

8 Cps LowerLimit

◇ Displayed only when **Response Mode** = ***PULSE RATE LIMITS*** .

Use this function for example to freeze the measured value when closing the shielding. If the shielding is opened again, then the time until the measured value becomes stable again is reduced.

Enter a value greater than zero to enable the lower count rate threshold. If the current count rate threshold falls below the lower threshold, the measurement will be stopped until the count rate threshold is exceeded again. When the measurement is stopped, the measured value and the current output are "frozen".

2.19 Cal Parameter

Menu path: **Device Config ▶ Setup ▶ Cal Parameter**.

In this menu you can calibrate and adjust the measuring system and set the parameters needed to perform the measurement.

Readjustment of an already calibrated measurement:

The count rates in this menu and the submenus are not decay compensated[1]. For this reason, after several weeks the calibration characteristic curve cannot be changed using data from **Cal Parameter**; rather, it must be changed using the values from **Meas Parameter**. These values correspond to the data the LB 480 is currently using to run measurements. The data in **Meas Parameter** also include the decay compensated count rates of the calibration points which were used last to calibrate the LB 480. Select **Recall** to obtain the decay compensated values. The current values from **Meas Parameter** (**Device Config ▶ Meas Parameter**) are copied back here.

IMPORTANT
*Changes in these parameters have an influence on the measurement only when you select the **Calibrate** command.*

Explanation "decay compensation":

Each source loses activity with time and becomes weaker. This is known as source decay. For this reason, the count rate measured at the detector decreases in the course of time. This process is mathematically reproducible and is automatically compensated - decay compensated - in this device.

1 Cal Points

This menu is used to determine the calibration points. The count rates for each calibration point are read in along with the current temperature (if a Pt100 is connected).

The type and manner of the calibration is selected from the **Cal Settings** menu under **Calibration Method**.

Only those parameters will be displayed that are required for each calibration method (**Calibration Method**).

2 Cal Settings

On this menu you enter the basic detector-specific parameters that need to be set before calibration.

3 Product Conditions

On this menu you enter the basic product-specific parameters that need to be set before calibration.

4 Adapt Calibration

The menu contains functions to take over older calibration data.

1. Each source will lose activity over time and become weaker; this is called source decay. For this reason, the count rate measured at the detector decreases in the course of time. The process can be calculated using a mathematical function and is automatically compensated for by the SENSseries detectors.

5 Calibrate

With this menu item you enable the calibration data determined during the measurements. In this case, the calibration data are transferred from **Cal Parameter** to **Meas Parameter**. Thus, the detector will get a new calibration which in the future will be used to determine the measured values.

After the calibration, a status message is displayed, indicating if the activation of the calibration data has been carried out successfully. If not, the measurement parameters are unchanged. Possible status messages are:

- ***0-OK***

  The calibration carried out is OK.

- ***1-ERROR BACKGROUND***

  The count rate of the background radiation is higher than that for the calibration points for empty or full (**Cal Point 0%** or **Cal Point 100%**).

- ***2-ERROR MISSING CALIBRATION POINT***

  The number of calibration points is not sufficient. Depending on the calibration type, at least the following number of calibration points is required:
  - ***DIRECT ENTRY***: none
  - ***1-POINT***: one
  - ***LINEAR***: two
  - ***SQUARE***: three
  - ***CUBIC***: four

- ***3-ERROR NOT MONOTONOUS***

◇ Appears only with calibration type ***SQUARE*** and ***CUBIC***.

The calibration curve is not monotonous, i.e. two different readings can be interpreted for the same count rate.

Calibration curve must be visually inspected and qualified. Restricting the measuring range may be helpful.

- ***4-DATE ERROR***

  A date is still set to the default value of 1.1.2000. At **Calibrate**, check the **Date** parameter. At **Restore**, check the date in **Restore Date**.

- ***5-CHECK ERROR***

  The status of the calibration parameters could not be fully verified. In this case, repeat the calibration. If the error occurs again, replace the detector, at least the detector electronics.

Please keep in mind to reset the parameters **Factor** and **Offset** at **Calibrate**.

5 Recall

Allows you to copy the current data set from **Meas Parameter** to **Cal Parameter**. This allows you to edit the valid parameters or read them in again, without this having an impact on the measurement and without having to read in all parameters again. After you have finished editing, you can activate the changed settings with **Calibrate**.

The use of **Recall** is also necessary because the count rates in the calibration parameters (**Cal Parameter**) are not decay compensated, unlike the count rates of the measuring parameters (**Meas Parameter**).

IMPORTANT
***Recall** overwrites all settings of the **Cal Parameter** menu.*

2.20 Cal Points

Menu path: **Device Config ▶ Setup ▶ Cal Parameter ▶ Cal Points**.

IMPORTANT
*Changes in this parameter group have an effect only when you call **Calibrate** (**Device Config ▶ Setup ▶ Cal Parameter ▶ Calibrate**, page 3-209).*

This menu allows you to adjust the measuring system.

1 ReadIn

Start reading-in the count rates. While the count rate is read in, the average is calculated and displayed continuously. Under **ReadIn Time** (**Cal Settings**) you define the read-in period.

First choose which calibration point you want to read in:

- ***BACKGROUND***

◇ Not required for CrystalSENS (50/50).

With SuperSENS and UniSENS you have to measure the background (**Background**) to enable the detector to correctly compensate for the decay of the radiation source.

Before taking measurements, make sure you do not measure any radiation from the radiation source

The easiest way to ensure this is if the source is not yet mounted. Otherwise, close the beam path and fill the container in addition.

- ***ACTIVE POINT***

  The count rate for the calibration point displayed under **Point No. Cal.** is read in.

  When reading-in the count rates, the time remaining up to the end of the operation is displayed. Finally, you are prompted to confirm the detected count rate with ***OK***. To shorten the read-in process, you can stop any time by pressing ***OK***.

2 Background

◇ Only important for large-volume detectors such as SuperSENS or UniSENS (rod detectors).

The term background refers to the background radiation which is present in the environment. The background radiation has to be measured so that the detector can correctly compensate for the decay of the radiation source.

Select ***ReadIn*** to read in the count rate for the background radiation. If you already know the value, you can enter it here.

3 Cal Point No.

Indicates to which calibration point the parameters below refer, such as **Cal Density** and **Cal Rate**.

4 Cal Concentration

◇ The parameter appears only when suspension measurement is selected.

Enter here the analysis value of the concentration for the calibration point.

5 Cal Density

Enter here the analysis value for the calibration point.

If suspension measurement is selected, then this parameter indicates the density value converted from the concentration.

6 Cal Density TC

◇ Visible only when **Temp. Comp** = ***ON***.

Shows the compensated density value.

Depending on the temperature value measured while reading in the counting rate and the settings under **Product Conditions** the temperature-compensated density or concentration value is automatically determined here.

7 Cal Rate

Calibration count rate.

Select **ReadIn** to read in the count rate. If you already know the value, you can enter it here.

8 Cal Temp

◇ Visible only when **Temp. Comp** = ***ON***.

Saves the temperature measured during the reading in of the count rate.

9 Calibration Chart

Allows a clear presentation of the calibration points.

- **Max Nbr Cal Points**

  Displays the maximum possible number of calibration points.

- **Refresh Cal Table**

  Updates the calibration points contained in **Cal Table**.

- **Cal Table**

  Shows all calibration points in a table. You can edit the calibration points in this table.

- **Clear Table**

  Clears all calibration points in a table.

- **Calibration Curve**

  Shows all calibration points in a calibration curve.

10 Io Rate

◇ Displayed only when **Calibration Method** = ***DIRECT ENTRY***.

Io is the count rate at zero density. It is a theoretical value which is calculated from a calibration with one or several calibration points. If this value is already known, it can be entered here. The calibration can then be performed together with **A1**. Calibration points and lab analyses are not required here.

11 Coefficient A1

◇ Displayed only when **Calibration Method** = ***1-POINT*** or ***DIRECT ENTRY***

The absorption coefficient determines the sensitivity of the measurement.

– ***DIRECT ENTRY:***

  A1 has to be known and to be entered manually.

– ***1-POINT***:

  For density and suspension measurements, -0.066 can be used as default value for Cs-137 and -0.044 for Co-60 radiation sources, unless other values ??are known.

  These standard coefficients cannot be used with the unit % and length.

The absorption coefficient can be entered in two different ways.

Example with input value -0.066:

- -0,066
- -66e-3

Entering the value as a power of ten allows you to enter very small coefficients without any problems.

2.21 Cal Settings

Menu path: **Device Config ▶ Setup ▶ Cal Parameter ▶ Cal Settings**.

All parameters defining basic settings before calibration can be entered on this menu.

1 Nuclide

Enter here the isotope (nuclide) that is used in your source:

- ***Co-60***
- ***Cs-137***
- ***USER DEFINED***

This entry controls the automatic decay compensation. The correct entry is also important for a one-point calibration. The isotope used is listed on the type plate of the shielding and on your delivery documents. The item ***USER DEFINED*** allows you to use any isotope you want. In this case, the parameter **Half Life Time** is queried in addition.

What happens when you have selected the wrong isotope?

As a result of the wrong decay compensation, you will get a deviating display only after several weeks or months, with the deviation increasing over time.

2 Half Life Time

◇ Visible only when **Nuclide** = ***USER DEFINED***.

See **Nuclide**.

3 Calibration Method

Five different calibration methods are available. A quick reference guide can be found in chapter 5.3.

- ***DIRECT ENTRY***

  Allows you to easily enter the characteristic curve parameters **A1** and **Io**, provided these are already known or have already been calculated. Calibration points are not needed here.

- ***1-POINT***

  One calibration point is enough (count rate and lab analysis) when for the user the density lies in the normal operating range. In addition to this calibration point and depending on the source, you also have to enter the standard absorption coefficient **A1**:

  – 0.066 for Cs-137
  – 0.048 for Co-60

- ***LINEAR***

  You can enter up to 11 calibration points for calibration. These should also be fairly different in their density varies, but they should also lie within the measuring range.

  With **Calculate** the LB 480 draws a linear curve through the calibration points and calculates the characteristic curves in the form of a zero count rate and a linear (A1) calibration coefficient.

- ***SQUARE***

  At least 3 calibration points are required for this type of calibration.

  With **Calculate** the LB 480 draws a square curve through the calibration points and calculates the characteristic curves in the form of a zero count rate, a linear (A1) and a square (A2) calibration coefficient.

- ***CUBIC***

  At least 4 calibration points are required for this type of calibration.

  With **Calculate** the LB 480 draws a cubic curve through the calibration points and calculates the characteristic curves in the form of a zero count rate, a linear (A1), a square (A2) and a cubic (A3) calibration coefficient.

4 Measuring Path

The value to be entered is the length of the beam path through the measured product. With a 90° measuring path, this corresponds to the inner diameter of the pipe. Especially with the calibration ***1-POINT***, you have to enter this value exactly to the millimeter.

5 Unit Family

Select the unit family for the measurement. Depending on this entry, the relevant units are available for selection under **Unit**, such as:

- ***DENSITY*** (g/cm³, kg/m³, g/l, ...)
- ***LENGTH*** (m, mm, yard, ...)
- ***SUSPENSION*** (%sol-wt, g/l, °Be)

Please note: When selecting ***SUSPENSION***, the measurement operates in a mode in which the concentration level of a substance is measured, for example, the proportion of the solid in a carrier liquid (%sol-wt). Additional inputs for **Liquid Density** and **Solid Density** are required.

6 Unit

Select the unit in which the measured value is to be displayed. To select units that are not included in the list, you may need to change the **Unit Family**.

7 Lower Range Limit

Enter the lower limit of the measuring range where 4 mA is to be output.

8 Upper Range Limit

Enter the upper limit of the measuring range where 20 mA is to be output.

9 ReadIn Time

Define here the period of time over which the count rate is to be read-in with **ReadIn** for each calibration point.

The statistical variation of the count rate is averaged over this time period. The longer it is, the better the mean value. A time period of 30 s (default setting) is usually reasonable.

2.22 Product Conditions

Menu path: **Device Config ▶ Setup ▶ Cal Parameter ▶ Product Conditions**.

On this menu you enter the basic product-specific parameters that need to be set before calibration.

1 Temp Compensation

To make sure that temperature fluctuations in the product do not have any effect on the measured value, the measured density value has to be compensated using the current product temperature. First, you have to enter a reference temperature.

For a standard density measurement you now have to enter the values ??for **TC1** in g/cm3/°C or in g/cm3/°F. For concentration measurements where water is the carrier fluid, you can also enable the function ***WATER TC***.

For more information please see the section on temperature compensation on *page 3-276*.

The following parameters can be set:

- ***OFF***

  The temperature compensation is switched off.

- ***STANDARD TC***

  The standard temperature compensation is enabled. Enter the values ??for Ref Temp and TC1.

- ***WATER TC***

◇ Displayed only if ***SUSPENSION*** is selected. Can only be used when water is the carrier fluid for the solid.

An internally stored density temperature curve then allows the temperature to be compensated without requiring any further input.

2 Ref Temp

An entry is required if the **Temp Comp** is enabled, i.e. ***STANDARD TC*** was selected under **Temp Comp**.

Enter the mean product temperature over the year in °C or in °F.

3 TC 1

An entry is only required if ***STANDARD TC*** is selected at **Temp Comp**.

TC 1 the linear temperature coefficient. It is entered in g/cm^3/°C or in g/cm^3/°F. Exceptions are the units of length and the unit percent (density 3) where the temperature coefficient does not relate to g/cm^3 but directly to the respective unit.

A value of zero means that the compensation is turned off with **TC 1**.

IMPORTANT

The coefficient has to be entered as a positive value, i.e. without a negative algebraic sign if the density of the product decreases with rising temperature. Furthermore, TC1 has to be entered multiplied by 1000.

4 TC 2

An entry is only required if ***STANDARD TC*** is selected at **Temp Comp** and a square coefficient (TC 2) needs to be added to the linear temperature coefficient **TC 1**.

A value of zero means that the compensation is disabled with **TC 2**.

IMPORTANT

TC1 has to be entered multiplied by 1,000,000.

5 Temp Unit

Unit for the detector temperature.

6 Liquid Density

◇ Required only if ***SUSPENSION*** was selected.

Enter the density of the carrier liquid in g/cm^3. In water, for example 1.00g/cm^3. For solutions, you have to enter the density of the main component.

7 Solid Density

◇ Required only if ***SUSPENSION*** was selected.

Enter the density of the carrier liquid in g/cm^3. For solutions, you have to enter the density of the main component.

Enter the density (g/cm^3) of the solid, and for solutions the density of the second component.

Example with sand as a solid:

With sand, the value to be entered corresponds to the average density of each individual grain of sand. This value is approximately 2.65g/cm^3.

2.23 Adapt Calibration

Menu path: **Device Config ▶ Setup ▶ Cal Parameter ▶ Adapt Calibration**.

The menu contains functions to take over older calibration data.

1 Restore Upload

This feature helps you to use old calibration data again, for example, if the electronics had to be replaced and the old data is available.

The calibration data can then be entered manually or transferred as a file. Under **Restore Date** you have to enter the date of the old calibration data. You need to enable **Restore Upload** to transfer the data to the measuring parameters. The count rates are automatically decay-compensated.

IMPORTANT

Do not enable Calibrate, otherwise the old data will be transferred to the measuring parameters. You can enable Recall to update the calibration data again.

2 Restore Date

Works together with **Restore Upload**.

To transfer old calibration data decay-compensated to the measuring parameters, you must enter the date of the old data.

Then you have to transfer the calibration data to the measuring parameters with **Restore Upload**.

2.24 I/O Setup

Menu path: **Device Config ▶ Setup ▶ I/O Setup**.

This menu allows you to set the analog and digital inputs and outputs and the interfaces.

1 Current Output

Opens the menu with the settings for the current output (*page 3-219*).

2 Digital Output

Opens the menu with the settings for the digital output (*page 3-221*).

3 Pt 100

Opens the menu in which the Pt100 input can be adjusted

4 Digital Input

Opens the menu with the settings for the digital input (*page 3-225*).

5 HART Interface

Opens the menu with the settings for the HART® interface *(page 3-226)*.

2.25 Current Output

Menu path: **Device Config ▶ Setup ▶ I/O Setup ▶ Current Output**.

1 Current Loop Monitoring

Enable or disable the monitoring of the 4-20 mA current signal. Monitoring checks whether the set current is actually flowing in the current loop, and signals an error if any deviation is detected.

You have the following setting options:

- ***ENABLED***

  Monitoring is enabled. (Factory setting)

  Unless there are compelling reasons, you should keep this setting. If you enable the **Safety Mode**, ***ENABLED*** is set here automatically.

- ***DISABLED***

  Monitoring is disabled. The HART® Communicator outputs a corresponding message.

Tip

In case of a gross deviation or loose contact, monitoring may have the effect that the fault condition can only be reset by a software reset. The software reset menu can be done in the menu **Service** (**Device Config ▶ Setup ▶ Service ▶ Reset Device**, *page 3-227*) or by turning the power supply off and then on again.

2 Loop Alarm Type

Here you specify the fault current, i.e. the current that is to be output in case of error.

IMPORTANT
*In Safety Mode, the fault current is automatically set to **High**.*

You have the following setting options:

- ***High***

  In case of error the current output is set to 22 mA.

- ***Low***

  In case of error the current output is set to 2 mA.

- ***Hold Last Value***

  In case of error the current output holds the last measured value.

- ***Value***

  In case of error, the current output is set to the current value, which is set in **Error Current Value**.

3 Error Current Value

Here you define the fault current in mA if you have selected ***Value*** in the **Loop Alarm Type** parameter.

If you have selected ***High*** or ***Low***, then the appropriate current value is displayed here.

If you exceed the mA value, then ***Value*** is set in the **Loop Alarm Type** parameter.

4 Current Lower Limit

Lower limit of the current range for the 4-20 mA current output.

For adjustment purposes or to safely identify an over or under measuring range condition, the current range available for the measurement signal is extended beyond the standard range of 4 mA and 20 mA.

According to the Namur specifications (NE 43), the lower current value must not be less than 3.8 mA. The limits can be set within the range from 3.8 mA to 4 mA.

5 Current Upper Limit

Upper limit of the current range for the 4-20 mA current output.

For adjustment purposes or to safely identify an over or under measuring range condition, the current range available for the measurement signal is extended beyond the standard range of 4 mA and 20 mA.

According to Namur specifications (NE 43), the upper current value must not be higher than 20.5 mA. The limits can be set within the range from 20 mA to 20.5 mA.

6 D/A trim

Allows you to adjust the current output. You will need a current meter which has to be connected to the current loop. One method will take you through the adjustment.

2.26 Digital Output

Menu path: **Device Config ▶ Setup ▶ I/O Setup ▶ Digital Output**.

The digital output provides a wiring for different signals. Without additional I/O cards the digital output is an open collector which is switched fail safe. This means that the transistor is conductive, as long as no alarm is reported and is blocked if an alarm is signaled. For more information on the digital output, see *Volume 2, chapter 3, "Electrical Installation", page 2-115*.

IMPORTANT

*If you use the setting **NORMAL** in the menu **Error Handling** (**Device Config ▶ Setup ▶ Signal Condition ▶ Signal Parameter ▶ Error Handling**), only errors are reported via the current output. Alerts can then be received only through one of the following signal outputs:*

- *via the digital output as a binary signal*
- *via the HART® signal as a text message*

1 Digital Out Function

The digital output provides a wiring for different signals. Without additional I/O cards the digital output is an open collector which is switched fail safe. This means that the transistor is conductive, as long as no alarm is reported and is blocked if an alarm is signaled. For more information on the digital output, see *Volume 2, chapter 3, "Electrical Installation", page 2-115*.

IMPORTANT

*If you use the setting **NORMAL** in the menu **Error Handling** (**Device Config ▶ Setup ▶ Signal Condition ▶ Signal Parameter ▶ Error Handling**), only errors are reported via the current output. Alerts can then be received only through one of the following signal outputs:*

- *via the digital output as a binary signal*
- *via the HART® signal as a text message*

You have the following setting options:

- ***ALARM***

  The alarm is triggered when the limit value is exceeded or fallen below, i.e. it responds in parallel with the current output. The switching behavior depends on the selected output function min/max, as described in **Switch Function**.

- ***DET. TEMP***

  The alarm is triggered when the detector temperature is below or above the permissible temperature range. The temperature range is defined in **Sensor Temperature (Device Config ▶ Setup ▶ I/O Setup ▶ Digital Output ▶ Temp. Threshold Settings,** *page 3-223***)**.

- ***HOLD***

  The alarm is triggered when the measurement is on hold, i.e. the measured value is frozen. This can be caused, for example, by the digital input or by RID.

- ***WARNING + ERROR***

  The alarm is triggered when the detector signals an error or reports a warning. In *chapter 8* on *page 3-307* you find a list of possible causes and troubleshooting procedures.

- ***RAD. INTERF.***

  An alarm is triggered as soon as interference radiation is detected.

  See under **Rad. Interf.** in the menu **Signal Condition ▶ Signal Dependency** (see *page 3-205*).

2 Digital Out State

Displays the current value of the digital output. If the test mode is active, then the test value is displayed. The following functions can be displayed:

– ***Normal***

– ***Alarm***

3 Threshold Settings

Opens the menu in which you can set alarm limit values for the density.

4 Temp. Threshold Settings

Opens the menu for the temperature-related settings *(page 3-223)*.

2.27 Threshold Settings

Menu path: **Device Config ▶ Setup ▶ I/O Setup ▶ Digital Output ▶ Threshold Settings**.

1 Switch Function

Here you define whether the switching function for the digital output (open collector) is used as a High Alarm or Low Alarm. The switching direction ensures the fail-safe function of the digital output (open collector).

You have the following setting options:

- ***MAX***

  Alarm is triggered if the limit value is exceeded (high alarm).

- ***MIN***

  Alarm is triggered if the limit value is not reached (low alarm).

2 Threshold

Enter the limit value of the selected unit for the density or concentration where the alarm is to be triggered.

3 Hysteresis

The hysteresis prevents switching back and forth caused by statistical fluctuations of the measured values.

2.28 Temp. Threshold Settings

Menu path: **Device Config ▶ Setup ▶ I/O Setup ▶ Digital Output ▶ Temp. Threshold Settings**.

1 Temp. Upper Limit

Upper limit value for the detector temperature.

An alarm may be signaled via the digital output if this temperature is exceeded. To do this, set the digital output to the function ***DET. TEMP***. The alarm is also signaled when the minimum detector temperature (**Temp. Lower Limit**) is not reached.

Tip

You can use this feature, for example, as a pre-alarm, for the detection of an over-temperature, or to control the cooling water cycle of the detector so that the cooling water flow is started at elevated temperature.

2 Temp. Lower Limit

Lower limit value for the detector temperature.

An alarm may be signaled via the digital output if this temperature is not reached. To do this, set the digital output to the function ***DET. TEMP***. The alarm is also signaled when the maximum detector temperature (**Temp. Lower Limit**) is exceeded.

Tip

You can use this function as a pre-alarm for under-temperature, so that a possibly connected cooling water system does not freeze, or a heater is turned on.

3 Temp. Hysteresis

Hysteresis for the temperature limit values.

4 Device Temp.

Displays the temperature inside the detector.

2.29 Pt100

Menu path: **Device Config ▶ Setup ▶ I/O Setup ▶ Pt100**.

1 Pt100 Temp

Shows the current Pt100 temperature.

2 Pt100 Adjustment

Allows you to adjust the Pt100 input new. The adjustment has already been made at the factory. If an adjustment should be required, then this must take place at a resistance of 100Ω (max. ±1Ω).

3 Pt100 Fine Tuning

Allows a fine adjustment after **Pt100 Adjustment** was performed, when the temperatures in the upper temperature range cannot be displayed with sufficient accuracy. For this purpose, the current actual temperature can be entered. Alternatively, you can also use a known resistance (max. ±1% tolerance) to adjust the resulting temperature. In order to minimize calibration errors, the fine tuning should be carried out, if possible, using the maximum temperature possible during operation, but at least at more than 50°C.

2.30 Digital Input

Menu path: **Device Config ▶ Setup ▶ I/O Setup ▶ Digital Input**.

The digital input can be controlled by the process control system. The reaction occurs when a short circuit of the input takes place; the signal must be bounce-free.

IMPORTANT
*If **Safety Mode** is enabled, the digital input is disabled automatically.*

The digital input is only available as an option. It is available for versions with HART® signal, but not for detectors with fail-safe signal output.

1 Digital In Function

Here you can define the switching function of the digital input. You have the following setting options:

- ***OFF***

  The digital input is disabled.

- ***HOLD***

  The measurement is frozen (hold mode) as long as the contact is closed.

IMPORTANT
The digital input is optional and can be used only when the detector has been prepared accordingly.

2 Digital In State

Indicates whether the input is open or closed.

2.31 HART Interface

Menu path: **Device Config ▶ Setup ▶ I/O Setup ▶ HART Interface**.

1 Poll Addr

Shows the current polling address. The address can be set with **Set Poll Address**.

2 Set Poll Address

Allows you to set the polling address for multidrop operation.

Enter only a polling address > 0 if the multidrop mode is used to operate several HART® devices at one current loop. Otherwise, leave the value at 0, since with a polling address > 0 the current output has no function anymore.

To use the multi-drop mode the current output must be passive (sink mode).

Multidrop mode

The host terminal uses the multidrop mode to identify the field device if more than one HART® device is connected to the same HART® loop. From HART® 6, up to 63 HART® devices can be interconnected in one HART® loop. Each device must have a different polling address between 1 and 63.

If an address is set which is higher than 0, the Multidrop Mode is selected automatically and the current output is switched to a fixed current value of 4 mA. Then only the digital HART® communication will be available.

IMPORTANT

For safe HART® communication, the current output must have a minimum impedance of 250ohms and a maximum impedance of 500ohms.

3 Num Req Preams

Display of the requested preambles during communication between detector and communicator to initiate the start of communication.

The value is set to 3 and cannot be changed.

4 Num Resp Preams

Number of returned preambles during communication between detector and communicator to initiate the start of communication.

The default value is 5. At a higher number, the communication is slowed down slightly. The setting range is 5 to 20.

2.32 Service

Menu path: **Device Config ▶ Setup ▶ Service**.

This menu allows you to access various test functions, enter the license key and perform a detector reset.

1 PMT

Opens the menu showing the anode current of the photomultiplier (PMT) *(page 3-228)*.

2 Sensor Temperature

Opens the menu showing the various detector temperatures *(page 3-228)*.

3 Test

Opens the menu with the various test functions *(page 3-229)*.

4 Plateau

Opens the menu for the plateau measurement and display of the plateau values *(page 3-234)*.

5 License Key

The license key allows you to enable the detector for other applications (level, density). You can get a license key through your sales partner or directly from BERTHOLD TECHNOLOGIES GmbH & Co. KG.

6 Reset Device

The menu offers you several ways to reset the detector or certain functions:

- ***MODIFICATION LOG RESET***

  Deletes all entries in the **Modification Log**.

- ***ERROR LOG RESET***

  Deletes all entries in the **Error Log**.

- ***SW RESET*** (Software Reset)

  Starts the detector new. The function corresponds to the switching off and on of the supply voltage.

- ***FACTORY RESET***

  Resets most settings to factory default. Some settings, such as the adjustment of current output and the license key will be preserved.

2.33 PMT

Menu path: **Device Config ▶ Setup ▶ Service ▶ PMT**.

This menu allows the qualification of the photomultiplier (PMT) after consultation with BERTHOLD TECHNOLOGIES. Increased current values at the multiplier indicate a strong radiation levels (caused, for example, by weld testing), or a defect at the PMT, or the HV control.

1 HV Live — Displays the current HV (high voltage) at the photomultiplier. If **HV Mode** is set to ***AUTO*** (normal operation), the values in **HV Live** must change, viewed over several seconds.

2 HV Feedback — Display of the read back HV value which is actually present at the multiplier. The display is used to control the HV.

3 Meas CH CPS — Count rate in the measuring channel.

4 Control CH CPS — Count rate in the control channel.

5 Auxiliary CH CPS — Count rate in the auxiliary channel.

6 PMT Current — Displays the current anode current.

7 PMT Current Max — Display of the stored maximum value for the multiplier tube current (**PMT Current**).

8 Reset Current Extrema — Clears the maximum value of the multiplier tube current (**PMT Current Max**).

2.34 Sensor Temperature

Menu path: **Device Config ▶ Setup ▶ Service ▶ Sensor Temperature**.

On this menu you can view the various detector temperatures.

1 Device Temp. — Displays the current detector temperature. The temperature is measured in the electronics of the detector.

2 Device Temp. Min — Display of the lowest temperature measured.

3 Device Temp. Max — Display of the highest temperature measured.

4 Reset Temp Extrema — Clears the stored values in **Device Temp. Min** and **Device Temp. Max**.

2.35 Test

Menu path: **Device Config ▶ Setup ▶ Service ▶ Test**.

These menus allow you to perform various tests on the detector. All tests have a direct influence and are not delayed by the time constant.

If you lock the device with the password or if the Safety Mode is enabled, all test settings will be disabled automatically.

1 Test Settings

Opens the menu offering various test options for the detector *(page 3-229)*.

2 I/O Test Settings

Opens to the menu offering various test options for the digital inputs and outputs *(page 3-232)*.

2.36 Test Settings

Menu path: **Device Config ▶ Setup ▶ Service ▶ Test ▶ Test Settings**.

This menu allows you to check your calibration setting by simulating the measurement signal.

1 Meas Mode

Here you can check if the process value is correctly transmitted from the field device to the process control system.

To simulate a density reading, you have to:

4. Enter a value in **Density** (concentration).
5. Select ***FIXED VALUE*** at **Meas Mode**.

IMPORTANT
*After the test, do not forget to switch from **FIXED VALUE** back to **NORMAL**; otherwise your measurement signal will remain frozen at this value.*

2 Density

Enter the value to be simulated.

To enable the simulation, you must set ***FIXED VALUE*** at **Meas Mode**.

3 Cps Average Mode

This item allows you to check whether your calibration is correct. Enter a count rate and then check the simulated density reading.

To simulate a density reading via a count rate, you have to:

- ▶ Enter a count rate at **Cps Average Test**.
- ▶ Select ***FIXED VALUE*** at **Cps Average Mode**.

IMPORTANT
*After the test, do not forget to switch from **FIXED VALUE** back to **NORMAL**; otherwise your measurement signal will remain frozen at this value.*

4 Cps Average Test

Enter the value to be simulated.

To enable the simulation, you must set ***FIXED VALUE*** at **Cps Average Mode**.

5 Product Temp. Mode

This makes it possible to simulate temperature compensated calibration values. In addition to the count rate, the temperature can be entered here in addition at which the count rate was recorded. As a result, the laboratory density has to be displayed. In a multi-point calibration, deviations may occur due to the regression of the calibration curve.

To enter a test temperature, you have to:

- ▶ Enter a temperature value in **Product Temp. Test**.
- ▶ Select ***FIXED VALUE*** at **Product Temp. Mode**.

IMPORTANT
*After the test, do not forget to switch from **FIXED VALUE** back to **NORMAL**; otherwise the temperature signal will remain frozen at this test value.*

6 Product Temp. Test

Enter a temperature value in order to test the digital output as a signal output for over- or under-temperature.

To enable the simulation, you must set ***FIXED VALUE*** at **Product Temp. Mode**.

7 Device Temp. Mode

Allows you to verify if over- or under-temperature is signaled via the digital output. Enter a test temperature and then check the signal at the digital output.

To check the digital output as a temperature output, you have to:

- set the digital output to ***DET. TEMP***,
- enter a count rate in **Cps Average Test**,
- select ***FIXED VALUE*** in **Cps Average Mode**.

IMPORTANT
*After the test, do not forget to switch from **FIXED VALUE** back to **NORMAL**; otherwise the temperature signaling will be kept.*

8 Device Temp. Test

Enter a temperature value in order to test the digital output as a signal output for over- or under-temperature.

To enable the simulation, you have to set **Device Temp. Mode** to ***FIXED VALUE***.

2.37 I/O Test Settings

Menu path: **Device Config ▶ Setup ▶ Service ▶ Test ▶ I/O Test Settings**.

This menu allows you to perform various tests on the analog and the digital inputs and outputs.

1 Digital Out Mode

This allows you to check whether the signal from the digital output is correctly transmitted to the control system.

To enable the test, you have to:

- ▶ Select ***FIXED VALUE*** at **Digital Out Mode**.
- ▶ Enter ***CLOSED*** or ***OPEN*** at **Digital Out Test State**.

2 Digital Out Test State

Choose ***OPEN*** or ***CLOSED*** to check the appropriate reaction at the digital output.

To enable the simulation, you have to set **Digital Out Mode** to ***FIXED VALUE***.

3 Digital In Mode

Allows you to simulate a signal at the digital input and examine its impact on the detector.

To enable the test, you have to:

- ▶ Set a function for the digital input via **Digital In Function** (**Device Config ▶ Setup ▶ I/O Setup ▶ Digital Input ▶ Digital In Function**, *page 3-225*).
- ▶ Select ***FIXED VALUE*** at **Digital In Mode**.
- ▶ Enter ***CLOSED*** or ***OPEN*** at **Digital In Test State**.

IMPORTANT
*After the test, do not forget to switch from **FIXED VALUE** back to **NORMAL**; otherwise the signaling will be kept.*

4 Digital In Test State

Choose ***OPEN*** or ***CLOSED*** to check the appropriate reaction of the detector.

To enable the simulation, you must set ***FIXED VALUE*** at **Digital In Mode**.

5 Loop Current Mode

Indicates whether the current output is active or frozen. The following displays are possible:

- ***ENABLED***

  The current output is active.

- ***DISABLED***

  The current output is frozen.

The current output is frozen in the following cases:

– if it is set to fault current

– in multi-drop mode (**Set Poll Address**, see *page 3-226*)

– in test mode

6 Loop test

Allows you to selectively output current values at the current output. Thus you can check the correct function of the current output and the display value in the process control system. Enter the desired value in mA.

2.38 Plateau

Menu path: **Device Config ▶ Setup ▶ Service ▶ Plateau**.

This menu leads to the plateau measurement and to the display of the plateau values.

1 Plateau Measurement Leads to the plateau measurement (*page 3-234*).

2 Plateau View Enables the display of the plateau data in a table or as a plateau curve *(page 3-235)*.

3 Plateau Information General information on the plateau measurement *(page 3-236)*.

2.39 Plateau Measurement

Menu path: **Device Config ▶ Setup ▶ Service ▶ Plateau ▶ Plateau Measurement**.

These parameters determine how the plateau measurement is to be performed.

For information on how to perform a plateau measurement please refer to *chapter 6.1*, *page 3-283*.

1 HV Start Enter the HV start value in volts.

2 HV Stop Enter the HV stop value (end value of the measurement) in volts.

3 HV Step Enter the step size in volts, which should lie between the measuring points.

4 Meas. Time Enter the length of time over which each measuring point should be averaged, for example 20 s.

5 HV Mode

The menu item offers the following options:

- ***AUTO***

  Enables the automatic HV control. Set this operating mode for the normal measurement mode. This enables a temperature-stable operation of the detector.

- ***MANUAL***

  This setting is typically used for testing purposes only. You can specify, for example, the provisional operating point of the detector. The specified voltage must, however, lie in the plateau.

  As soon as you enable ***Manual***, the automatic HV control is switched off. The HV is then set to the value specified in **HV Manual**.

- ***PLATEAU***

  Starts the plateau measurement. The measurement mode is exited and the plateau of the multiplier which is used in the detector is measured. The measurement is done with the settings defined in the menu items **HV Start**, **HV Stop**, **HV Step** and **Meas. Time**.

  At the end of the plateau measurement the detector automatically switches back to **HV Mode**: ***AUTO*** or ***MANUAL***, depending on which mode was last set.

6 HV Live

Displays the current HV (high voltage) at the photomultiplier. If **HV Mode** is set to ***AUTO*** (normal operation), the values in **HV Live** must change, viewed over several seconds.

7 Cps Live

Shows the current non-averaged count rate.

2.40 Plateau View

Menu path: **Device Config ▶ Setup ▶ Service ▶ Plateau ▶ Plateau View**.

This menu allows you to display the plateau data in a table or as a plateau curve.

1 Refresh Plateau

Updates the plateau table by loading the data from the detector.

2 Plateau Table

Shows the plateau data points in a table.

3 Plateau Curve

Shows the plateau data points in a curve.

2.41 Plateau Information

Menu path: **Device Config ▶ Setup ▶ Service ▶ Plateau ▶ Plateau Information**.

General information on the plateau measurement.

1 Plateau Date

Shows the date of the last plateau recording.

No plateau recording exists, if the date 01/01/2000 is displayed.

2 Plateau Tab Entries

Displays the number of data points for the plateau measurement.

2.42 Meas Parameter

Menu path: **Device Config ▶ Meas Parameter**.

These menus show the currently valid measurement parameters.

1 Meas Data

Opens the menu showing the currently measured values *(page 3-237)*.

2 Meas Settings

Opens the menu showing the most important detector settings *(page 3-238)*.

2.43 Meas Data

Menu path: **Device Config ▶ Meas Parameter ▶ Meas Data**.

Shows the calibration curve and the calibration points used by the measurement. The values ??were calculated from the **Cal Parameter** menu with ***Calibrate*** and taken over.

1 Coefficient A1

Absorption coefficient 1.

Determines the slope and thus the sensitivity of the measurement.

2 Coefficient A2

Absorption coefficient 2.

Is calculated only for the calibration modes ***SQUARE*** and ***CUBIC***.

3 Coefficient A3

Absorption coefficient 3.

Is calculated only for the calibration mode ***CUBIC***.

3 Io Rate

Count rate calculated at density = 0.

4 Square Error

Shows the least squares for the current calibration with multi-point calibrations (at least three pairs of values ??are required).

The smaller the numerical value, the better the curve fitting. For values ??greater than 0.002, you should check your calibration for input errors; values ??below 0.0005 are very good.

5 Measuring Path

Enter the length of the absorption path (measuring path in the medium). Generally it corresponds to the inner diameter of the pipe. Especially with the calibration ***1-POINT***, you have to enter this value exactly to the millimeter.

6 Background

Shows the calibration value of the background radiation.

7 Measuring Table

After calibration, the calibration points are displayed here in a table.

2.44 Meas Settings

Menu path: **Device Config ▶ Meas Parameter ▶ Meas Settings**.

1 Nuclide

Display of the isotope (nuclide) selected for the calibration. It must be the same as the source which is used at the measuring site.

2 Cal Method

Indicates which type of calibration was last performed.

3 Temp Compensation

Shows which temperature compensation is used for compensation.

- ***OFF***

  The temperature compensation is disabled.

- ***STANDARD TC***

  The standard temperature compensation is enabled. The following settings are active:

  – Ref Temp
  – TC 1
  – TC 2

- ***WATER TC***

  The temperature compensation with water TC is enabled.

4 Ref Temp

Mean product temperature entered by the user.

5 TC 1

Linear temperature coefficient used to compensate the measurement, provided ***STANDARD TC*** has been selected.

A value of zero means that the compensation with **TC 1** is turned off.

6 TC 2

Square temperature coefficient used to compensate the measurement, provided ***STANDARD TC*** has been selected.

A value of zero means that the compensation with **TC 2** is turned off.

7 Liquid Density

Enter the density of the carrier fluid in g/cm^3. The value is only relevant if suspension measurement is enabled.

8 Solid Density

Enter the density of the solids in g/cm^3. The value is only relevant if suspension measurement is enabled.

2.45 Access

Menu path: **Device Config ▶ Access**.

On this menu you can enter the password, enable write protection to prevent configuration changes and activate the safety mode.

1 Password

Enter a password to protect the detector against unauthorized access. Then access to editable parameters is disabled. To undo the protection again, you must enter the password again.

You can choose any password you want; it may comprise a maximum of 8 characters or digits.

Tip

Write down your password to be able to unlock the detector later. Please contact BERTHOLD TECHNOLOGIES if you lose your password.

2 Write Protect

Indicates whether the detector is protected against changes in the settings (parameters).

- ***NO***

  The detector is not write protected, so that the settings can be edited.

- ***YES***

  The detector is write protected; settings cannot be edited, but they can still be displayed.

3 Safety Mode

Indicates whether the safety mode is enabled:

- ***ON***

  Safety mode is enabled.

- ***OFF***

  Safety mode is disabled.

4 Safety ON

The safety mode has to be enabled for safety-relevant applications.

IMPORTANT
Please note that this device does not yet have SIL certification, although the software is already prepared for it.

In safety mode, safety-limiting values are set to a safety-compatible setting. In addition, you will be prompted to protect the detector with a password.

The following settings are set automatically when safety mode is enabled:

- Current output monitoring: = ***ENABLED***
- HV Mode = ***AUTO***
- Test Settings = ***NORMAL***
- Error Handling = ***SENSITIV***
- Digital inputs: = ***OFF***
- Multidrop: Poll Addr = ***0***

IMPORTANT
HV default *must have the correct value (operating point).*

If you have changed the factory-set HV value, you have to determine it again. Determine the operating point and enter this value in **HV Default** (**Device Config ▶ Setup ▶ Sensor Configuration ▶ Sensor Settings ▶ HV Default**, *page 3-201*). See also *chapter 6.1*, *page 3-283*.

Tip
The operating point in new detectors is usually between 400 to 900 V. If you get a different value, please contact BERTHOLD TECHNOLOGIES or your local representative.

5 Safety OFF

Disables the safety mode. Keep the password handy in case you want to make changes, because you will need any time you make changes.

If you disable the safety mode, the following settings are made automatically:

– the detector is unlocked, i.e. **Write Protect** is set to ***OFF***

– **Error Handling** is set to ***NORMAL*** *(page 3-202).*

– **Response Mode** is set to ***DISABLED*** *(page 3-209)*

6 Lock Device Status

Indicates whether the detector is enabled or disabled for access to the HART® interface by other users.

7 Lock/Unlock Device

Locks or unlocks the detector to prevent access by other users to the HART® interface.

2.46 Identification

Menu path: **Device Config ▶ Identification**.

This menu shows various detector parameters, such as model, device ID, software and hardware revision.

1 Location

Opens the menu showing information about the tag *(page 3-242)*.

2 Device Information

Opens the menu showing information about the detector *(page 3-243)*.

3 Device Revision

Opens the menu showing the hardware and software revisions *(page 3-243)*.

2.47 Location

Menu path: **Device Config ▶ Identification ▶ Location**.

This menu shows information about the tag.

1 Tag

Shows the tag number. You can edit information, any text is possible. Up to 8 characters.

2 Long tag

Shows the tag number. You can edit information, any text is possible. Up to 32 characters.

3 Descriptor

Shows a tag description. You can edit information, any text is possible.

4 Message

Shows a message. You can edit information, any text is possible.

2.48 Device Information

Menu path: **Device Config ▶ Identification ▶ Device Information**.

This menu shows information about the detectors.

1 Device Type

Shows the model name of the SENSseries. This information cannot be edited by the user.

2 Device Id

Identification number of the detector. It shows the specific HART® device number. This information is set up by BERTHOLD TECHNOLOGIES and edited be changed by the user.

3 Manufacturer

Shows the manufacturer's name. This information cannot be edited by the user.

4 Final Assembly Num

Number for identification of the detector.

2.49 Device Revision

Menu path: **Device Config ▶ Identification ▶ Device Revision**.

This menu shows the hardware and software revisions.

1 Universal Rev

Shows the revision of the specific universal HART® command set.

For the SENSseries you need the Universal Commands for HART® 6 or higher. This requires that the 375 Field Communicator of the Emerson Process Management GmbH & Co. OHG or a compatible model is used which supports enhancements.

If the Communicator has a lower version than HART® 6, then the so-called *Generic DD* will be started. The Generic DD does have a HART®-specific command set, but this does not sufficient for the SENSseries.

2 Field Dev Rev

Shows the compatibility of the detector with DD on the Communicator. This number, e.g. 2, indicates that DD Revision 2 is necessary which supports the full functional range of the detector. See also *chapter 7.6*, *page 3-302*.

3 Software Rev

Displays the software revision (embedded software). This information depends on the currently installed firmware and cannot be changed.

4 SW Revision

Software revision with presentation according to NAMUR.

5 SW Revision Date

Date of the software revision.

6 Hardware Rev

Shows the hardware revision. This information is set up by BERTHOLD TECHNOLOGIES and edited be changed by the user.

2.50 Diagnostic

This menu provides status and error information and allows you to view the error logs and setting changes logs (parameter changes).

Tip
In *chapter 8* on *page 3-307* you find a list of possible causes and troubleshooting procedures.

1 Operating Status

Opens the menu showing the operating status *(page 3-244)*.

2 Log

Opens the menu showing the logs for error and setting changes *(page 3-247)*.

3 Safety

The status of all settings listed here must be ***OFF***, when you have enabled **Safety ON** (**Device Config ▶ Access**, *page 3-239*).

4 Error Status 100 ... 907

Here you can check the status of all error messages that are possible in the detector.

- ***OFF*** = error free
- ***ON*** = an error is indicated

2.51 Operating Status

Menu path: **Diagnostic ▶ Operating Status**.

1 Device Status

Displays the current device status (standard HART® command).

2 Ext dev status

Shows the extended device status (standard HART® command).

3 Device Variables Status

Opens the menu showing the status of the detector variable (standard HART® command, *page 3-245*).

4 Config Change Status

Opens the menu showing the status of the detector variable (standard HART® command, *page 3-245*).

5 Lock Dev Status

Indicates to what extent the device is locked against access to the HART® interface.

- ***Device is Locked***
- ***Lock is Permanent***
- ***Locked by Primary Master***

6 Error Status

Opens the menu showing the status of the detector variable (standard HART® command, *page 3-245*).

2.52 Device Variables Status

Menu path: **Diagnostic ▶ Operating Status ▶ Device Variables Status**.

1 Data Quality

Indicates the quality of the main variables (standard HART® command).

2 Limit Status

Indicates whether the limits of the main variables were reached (standard HART® command).

2.53 Config Change Status

Menu path: **Diagnostic ▶ Operating Status ▶ Config Change Status**.

1 Modification Counter

Shows the number of parameter changes carried out since the last reset with **Reset Modification Flag**.

2 Reset Modification Flag

Sets the Modification Counter to 0.

2.54 Error Status

Menu path: **Device Config ▶ Diagnostic ▶ Operating Status ▶ Error Status**.

1 Meas Setup Status

Displays the status of the calibration parameters. The status is updated after each decay compensation (at 09:01 h) and after each date change. It informs you that the measurement is still working safely. One of the following status messages is displayed:

One of the following status messages is displayed:

- ***0-OK***

  The calibration carried out is OK.

- ***1-ERROR BACKGROUND***

  The count rate of the background radiation is higher than that for the calibration points for empty or full (**Cal Point 0%** or **Cal Point 100%**).

- ***2-ERROR MISSING CALIBRATION POINT***

  The number of calibration points is not sufficient. Depending on the calibration type, at least the following number of calibration points is required:

  – ***DIRECT ENTRY***: none
  – ***1-POINT***: one
  – ***LINEAR***: two
  – ***SQUARE***: three
  – ***CUBIC***: four

- ***3-ERROR NOT MONOTONOUS***

◇ Appears only with calibration type ***SQUARE*** and ***CUBIC***.

The calibration curve is not monotonous, i.e. two different readings can be interpreted for the same count rate.

Calibration curve must be visually inspected and qualified. Restricting the measuring range may be helpful.

- ***4-DATE ERROR***

A date is still set to the default value of 1.1.2000. At **Calibrate**, check the **Date** parameter. At **Restore**, check the date in **Restore Date**.

- ***5-CHECK ERROR***

The status of the calibration parameters could not be fully verified. In this case, repeat the calibration. If the error occurs again, replace the detector, at least the detector electronics.

2 Operating Mode

Displays the operating status of the measurement. One of the following status messages is displayed:

– ***RUN***

The measurement is in the normal measurement mode.

– ***WARNING***

A warning of error category **2** is displayed and the following steps are carried out:

– entry in the error log (the error is stored in the error memory)
– the error will be reported digitally via HART®
– the error is reported binary via the digital output (Digital Out) if this output has been set to ***WARNING + ERROR*** (see *chapter 2.26*, *page 3-221*)

If the error is no longer displayed in **Active Error**, you can check the error log (**Device Config ▶ Diagnostic ▶ Log**, *page 3-247*). In *chapter 8* on *page 3-307* you find a list of possible causes and troubleshooting procedures.

– ***ERROR***

An error of error category **1** is displayed and the following steps are carried out:

– entry in the error log (the error is stored in the error memory)
– the error will be reported digitally via HART®
– the error is reported binary via the digital output (Digital Out) if this output has been set to ***WARNING + ERROR*** (see *chapter 2.26*, *page 3-221*)
– the fault current goes to 24mA

If the error is no longer displayed in **Active Error**, you can check the error log (**Device Config ▶ Diagnostic ▶ Log**, *page 3-247*). In *chapter 8* on *page 3-307* you find a list of possible causes and troubleshooting procedures.

– ***SHUTDOWN***

A serious error of error category **0** is displayed and the following steps are carried out:

– entry in the error log (the error is stored in the error memory)
– the error will be reported digitally via HART®
– the error is reported binary via the digital output (Digital Out) if this output has been set to ***WARNING + ERROR*** (see *chapter 2.26*, *page 3-221*)
– the fault current goes to 24 mA
– the measurement is stopped.

The error remains active until it is eliminated and a reboot or software reset has been carried out. If the error does not disappear after restart (power off and then on, or software reset, *page 3-227*), then the detector must be replaced.

– ***HOLD***

The measurement is in the hold state, which means that the measured value and the current output signal are frozen. This status can occur under the following conditions:

– the plateau recording is running
– interference radiation is detected
– the digital input (option) is shorted

– ***TEST***

- A test value has been enabled in the menu **Service ▶ Test** (*page 3-227*).

3 Error Code

Indicates if an error message is present.

If no error is present, then ***0*** is displayed here.

An error message is displayed with a three digit number.

The cause of the error and suggestions for correcting the error are described in *chapter 8*, *Error Handling*.

4 Acknowledge Error

Acknowledges the currently pending error.

2.55 Log

Menu path: **Device Config ▶ Diagnostic ▶ Log**.

This menu provides information about the history of the error messages and parameter changes. Up to 25 events can be entered.

1 Error Log

Opens the menu displaying the errors that have occurred.

2 Modification Log

Opens the menu showing the history of the settings made.

2.56 Error Log

Menu path: **Device Config ▶ Diagnostic ▶ Log ▶ Error Log**.

Update the error log by selecting **Refresh Error Log** before you select one of the following menu items. Otherwise, no or only old entries may be displayed.

Tip
In *chapter 8* on *page 3-307* you find a list of possible causes and troubleshooting procedures.

1 Refresh Error Log

Updates entries in the error log table.

2 Error Log Table

The last 25 errors are displayed in a table. The table contains the error code and the time the error occurred. The prerequisite is that the date and time were set correctly.

3 Reset Error Log

Deletes all entries in the error log.

4 Error Code

Indicates if an error message is present.

If no error is present, then ***0*** is displayed here.

An error message is displayed with a three digit number. The cause of the error and suggestions for correcting the error are described in *chapter 8*, *Error Handling*.

5 Acknowledge Error

Acknowledges the currently pending error.

2.57 Modification Log

Menu path: **Device Config ▶ Diagnostic ▶ Log ▶ Modification Log**.

Update the modification log by selecting **Refresh Modification Log** before you select one of the following menu items. Otherwise, no or only old entries may be displayed.

1 Refresh Modification Log

Updates the modification log.

2 Modification Log Table

The last 25 modifications are displayed in a table. The table includes the old and the new parameter value and the time the change was made. The prerequisite is that the date and time were set correctly.

3 Reset Modification Log

Deletes all entries in the modification log.

3

Getting Started via the HART® Communicator

The measuring system SENSseries LB 480 is compatible with the 375 Field Communicator (HART® Communicator, HART = Highway Addressable Remote Transducer) by Emerson Process Management GmbH & Co. OHG. Other HART® compatible communicators may also be used, provided they support Enhancements. The HART® Communicator Model 275 by Emerson Process Management GmbH & Co. OHG *cannot* be used.

⚠ WARNING

Make sure before commissioning that

- the detector is not damaged,
- the detector is properly installed,
- the connections have been carried out properly,
- the cables are properly inserted,
- unused cable entries are sealed with plugs certified according to Directive 94/9/EC,
- the cover is tight,
- the dummy plugs and cable glands or conduits are tight.

The measuring system can be taken into operation either via the *HART® Communicator* or via a *PC and the SIMATIC PDM* software.

Basically, the procedure for getting started is nearly identical for both versions. The difference is only the interface through which the measuring system communicates.

This chapter describes how to take the measuring system into operation via the *HART® Communicator*. Previous knowledge of the functionality of the *HART®* Communicator used is assumed.

3.1 Steps for Getting Started

Step	Activity	Page
1	Check if the Device Description is installed on the HART® Communicator (see HART® Communicator User's Manual); if necessary, have it installed by the manufacturer.	–
2	Connect HART® Communicator.	*3–178*
3	Turn HART® Communicator on (see HART® Communicator User's Manual).	–
4	Calibrate measuring system.	*3–253*
5	Create setup protocol.	*3–321*

4 Quick Guide to Calibration

Prerequisites

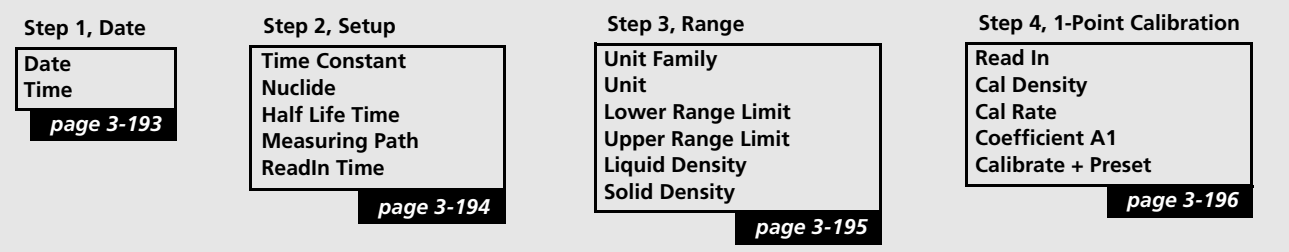
- The detector is installed and is supplied from the mains.
- The factory setting of parameters have not been changed yet. Otherwise, perform a factory reset (see *chapter 5.1.1*).
- The user is familiar with the basic calibration of a radiometric measurement.
- The user is aware of the risks of incorrect calibration.
- Communication with the HART® Communicator is established.
- Under **Unit Family** in Step 3, select ***DENSITY 1*** or ***SUSPENSION 1***.

The following calibration is based on a one-point calibration, which requires only one calibration point.

Tip
Set the date and time when the error message 105 appears.

▶ Select the menu item **Quick Start**: **Device Config ▶ Setup ▶ QuickStart**.

QuickStart Menu



Step 1 - Date/Time

▶ Check and update the date.

▶ Check and update the time.

Step 2 - Setup

▶ Select **Nuclide**: ***Cs-137*** or ***Co-60*** (see type plate of the source shielding).

▶ Enter the measuring path in the product in **Measuring Path**.

Step 3 - Range

- Under **Unit Family**, select ***DENSITY 1*** or ***SUSPENSION 1***. If you have selected ***SUPENSION 1***, you also have to enter the liquid and solid density.
- Select the unit you need in **Unit**.
- Enter the lower measuring range in **Lower Range Limit**.
- Enter the upper measuring range in **Upper Range Limit**.

Step 4 - Calibration Points

Adjust calibration point

Source is mounted and beam path is open. The current density or concentration is at a normal value, or in the middle measuring range.

- Select **ReadIn** and wait until the measurement time is over.

Enter density value

Take a lab sample at the same time to adjust the calibration point.

- Select **Cal Density** and enter the lab value.

Enter calibration coefficient

- Depending on the nuclide, enter here one of the following coefficients:
  - 0.066 (for Cs-137)
  - 0.048 (for Co-60)

Calibration

- Select **Calibrate + Preset**.

The message ***0-OK*** must be displayed, otherwise correct the calibration error as per the error message and reselect **Calibrate + Preset**.

On the following pages you can find detailed calibration instructions.

Tip

Always carry out a test calculation after every calibration. This will ensure that your calibration data are plausible and the detector is set correctly (see *chapter 2.36*, *page 3-229*, **Cps Average Mode** and **Cps Average Test**).

5 Calibration

NOTICE

Errors in the calibration or in the parameter setting can lead to false results. This may possibly lead to loss of production, or to damage in the system.

For testing, we recommend using the test settings in the Service menu to simulate the calibration points.

Basically we recommend to have commissioning carried out by the BERTHOLD TECHNOLOGIES service.

Prerequisites for calibration with the HART® Communicator

- The detector is installed correctly and is powered from the mains (see *Volume 2*, *chapter 2* and *3*).
- The HART® Communicator is connected to the current loop.

5.1 Preparing Calibration

For correct calibration of the measuring system, you have to ensure that the detector and basic settings are correct.

▶ Turn the HART® Communicator on.

After power on, the Start menu appears.

Tip

Push ***HOME*** to return from any level back to the Start menu.

If the detector has been in stock for a long time, it may happen that the internal timer no longer displays the current date. In this case, the error message *105 Real time clock not valid* is displayed. Update the date and time to reset the error message (see *chapter 2.13*, *page 3-199*).

If you are sure that the detector and basic configuration are correct, you can start with the calibration of the measuring system immediately as described in *chapter 5.2*.

Otherwise proceed as follows:

▶ If the device is still locked with a password, undo the password protection (see *page 3-239*).

▶ Reset the detector to factory defaults (see *chapter 5.1.2*)

▶ Adjust the value for HV default (see *page 3-254*). This is usually not necessary, since the detector is factory-calibrated.

5.1.1 Reset SENSseries to Factory Settings

If the Start menu is not already displayed, push ***HOME*** to go to the Start menu.

- Select **Device Config ▶ Setup ▶ Service ▶ Reset Device** .
- Select ***FACTORY RESET*** and confirm the security prompt.

  After successful reset, the message *Device is reset!* appears.
- Now turn the HART HART® Communicator OFF and ON again.

The parameters in the detector are now again identical with the factory setting (delivery state).

5.1.2 Adjust HV Default

HV Default has already been determined and set by BERTHOLD TECHNOLOGIES. If this value deviates during the *first commissioning* by more than 5% from **HV Live**, then you have to adjust **HV Default** new.

The adjustment of **HV Default** is only successful if the current count rate in the
CrystalSENS is at least at 200 cps. With SuperSENS and UniSENS the count rate is irrelevant.

If the Start menu is not already displayed, push ***HOME*** to go to the Start menu.

- Select **Device Config ▶ Setup ▶ Sensor Configuration ▶ Plateau ▶ Sensor Settings**.
- Select ***HV Mode* AUTO**, if this is not already set.
- Save the changes with ***SEND***.
- Wait until the HV value (**HV Live**) has been adjusted.

  This takes about 2 minutes in the CrystalSENS and 30 minutes in the SuperSENS and UniSENS.
- Read off the value **HV Live**.
- Enter the value read-off at **HV Default**.
- Save the changes with ***SEND***.

This completes the adjustment of the HV Default value.

5.2 Calibration with Quick Start

QuickStart allows you to quickly take the detector in operation, without having to deal with the complete menu. Additional functions can be enabled any time on the main menu after the calibration.

For calibration in the **Quick Start** menu, you have to set the required values ??in the 4 Quick Start menus and then complete the calibration with **Calibrate + Preset**.

Please note that the function **Calibrate + Preset** in the **Quick Start** menu will automatically set the following parameters:

- Temp Comp = OFF
- Calibration Method = 1-Point
- Background = 0
- Factor = 1
- Offset = 0

If other settings are required, the calibration has to be carried out in the **Cal Parameter** menu.

This chapter describes the calibration in the **Quick Start** menu in detail. A quick reference guide can be found in *chapter 4*.

The **Quick Start** menu supports a one-point calibration which requires only one calibration point.

In many cases, a one-point calibration suffices, especially if the measurement is integrated into a control system designed to hold the process value. In other cases, it quickly leads to a display of the measured value and makes it easy to quickly get familiar with the operation of the system. Advanced options are available on the **Cal Parameter** menu.

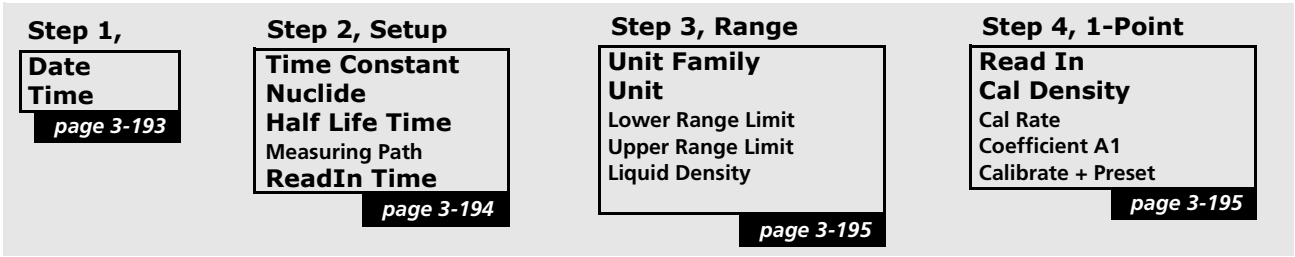
The following reasons could make it necessary that you carry out the calibration on the main menu under **Cal Parameter** rather than in **Quick Start**, e.g.:

- because the calibration coefficient is unknown
- because the reading must not only be reproducible over the entire measuring range, but also accurate, so that a multi-point calibration is required
- because individual laboratory values ??cannot be determined with sufficient accuracy, so that several laboratory analyses are required to obtain a sufficient accuracy
- because the calibration curve is not linear, i.e. more than one calibration coefficient is required
- because a temperature compensation measurement is required
- because you want to enter a known calibration curve based on the zero count rate and the absorption coefficient
- because a SuperSENS detector is used for the density measurement and the background has to be entered for optimal long-term stability of the measurement. We will advise you if you have any doubts as to the correct procedure.

If the Start menu is not already displayed, push ***HOME*** to go to the Start menu.

▶ Select **Device Config ▶ Setup ▶ Quick Start**.

QuickStart Menu



This menu contains four steps (**Step 1** to **Step 4**) with the corresponding submenus. Go through the individual steps menu item for menu item.

5.2.1 Step 1

▶ Enter the current date (**Date**) and time (**Time**). The Date is specified in the format MM/DD/YYYY, the Time in the format hh:mm:ss.

The correct date is important for the automatic decay compensation of the isotope. Since the activity of the source diminishes with time, the calibration count rates will be compensated automatically through the date. The decay compensation takes place daily at 09:01 h. Time differences have no impact on the correction of the decline in activity. However, the correct time is helpful to check the detector function: In case of error, you can see in the error log when the error occurred.

5.2.2 Step 2

Time Constant

▶ Enter the desired time constant.

The time constant smoothes the output signal. Statistical fluctuations and process-related fluctuations can be smoothed. A time constant of 60 s is usually reasonable.

Nuclide

▶ Enter here the isotope (nuclide) that is used in your source:

- ***Co-60***
- ***Cs-137***
- ***USER DEFINED***

This entry controls the automatic decay compensation. The correct entry is also important in a one-point calibration and for gas density compensation. The isotope used is listed on the type plate of the shielding and on your delivery documents. The item ***USER DEFINED*** allows you to use any isotope you want. In this case you must enter the half-life of the nuclide used in **Half Life Time**.

What happens when you have selected the wrong isotope?
As a result of the wrong decay compensation, you will get a deviating display only after several weeks or months, with the deviation increasing over time.

Measuring Path

▶ Enter the measuring path in the product. With a standard 90° measuring path on a pipe that would be, for example, the inner diameter of the pipe.

ReadIn Time

▶ Define here the period of time over which the count rate is to be read-in for each calibration point.

The statistical variation of the count rate is averaged over this time period. The longer it is, the better the mean value. A time period of 180 s (default setting) is usually reasonable.

5.2.3 Step 3

Unit

▶ Select the unit you need in **Unit**.
If you do not find the required unit in the selection list, you can switch to another **Unit Family** to select other units.

Lower Range Limit

▶ Enter the lower measuring range in **Lower Range Limit**.

Upper Range Limit

▶ Enter the upper measuring range in **Upper Range Limit**.

If you have selected ***SUPENSION*** in **Unit Family**, you also have to enter the liquid and solid density.

When will the unit family SUSPENSION be used?

– If you have a mixture of one solid and one liquid, and the measured value is to be output as concentration value (%, g/l, Brix).

– To allow for the non-linear relationship between density and concentration with only one absorption coefficient.

– To calibrate a concentration measurement with a one-point calibration.

5.2.4 Step 4

The current density or concentration is at a normal value, or in the middle measuring range.

ReadIn

▶ Start reading-in the count rates with **ReadIn**. While the count rate is read in, the average is calculated and displayed continuously. Under **ReadIn Time** (*Quick Start,* Step 2: Setup) you define the read-in period.

When reading-in the count rates, the time remaining up to the end of the operation is displayed. Finally, you are prompted to confirm the detected count rate with ***OK***. To shorten the read-in process, you can stop any time by pressing ***OK***.

▶ As you read in the count rate, you also need to take a sample of the product in order to determine the density or the concentration in the laboratory. The sample must be representative, i.e.:

– it must be taken in the immediate vicinity of the measuring point

– it must be taken promptly after the reading-in of the count rate

– the product density must not fluctuate during this period but must be constant

Depending on the sampling site, it is best to let a sufficient amount initially run into another container before taking the actual sample. This prevents that a product located in a branch line may possibly distort the lab sample.

Depending on the laboratory facilities, it is advisable to take duplicate samples and to have them analyzed in the lab at different times.

Cal Density

▶ Enter the lab value.

Cal Coefficient A1

▶ If you have selected ***DENSITY 1*** (or ***SUSPENSION 1***) under **Unit Family**, you can enter the following standard coefficients:

– 0.066 (for the nuclide Cs-137)

– 0.048 (for the nuclide Co-60)

In the other case, and if you do not know the coefficient, you need to perform a two- or multi-point calibration under **Cal Parameter**.

Calibrate + Preset

With this menu item you enable the calibration data determined during the measurements. The calibration data are transferred to the parameter set **Meas Parameter**. Thus, the detector will get a new calibration which in the future will be used to determine the measured values.

After the calibration, a status message is displayed, indicating if the activation of the calibration data has been carried out successfully. If not, the measurement parameters are unchanged. Possible status messages are:

- ***0-OK***: The calibration carried out is OK.
- ***1-ERROR BACKGROUND***:
  The count rate of the background radiation is higher than that for the calibration points for empty or full (Cal Point 0% or Cal Point 100%).
- ***2-MISSING CALIBRATION POINT***:
  The number of calibration points is not sufficient. Depending on the calibration type, at least the following number of calibration points is required:
  – ***DIRECT ENTRY***: none
  – ***1-POINT***: one
  – ***LINEAR***: two
  – ***SQUARE***: three
  – ***CUBIC***: four
- ***3-ERROR NOT MONOTONOUS***:
  The calibration curve is not monotonous, i.e. two different readings can be interpreted for the same count rate.

◇ Appears only with calibration type ***SQUARE*** and ***CUBIC***.

Calibration curve must be visually inspected and qualified. Restricting the measuring range may be helpful.

- ***4-DATE ERROR***:
  A date is still set to the default value of 1.1.2000. At **Calibrate**, check the **Date** parameter. At **Restore**, check the date in **Restore Date**.
- ***5-CHECK ERROR***:
  The status of the calibration parameters could not be fully verified. In this case, repeat the calibration. If the error occurs again, replace the detector, at least the detector electronics.

The following settings are made automatically at **Calibrate** + **Preset**:

- **Temp Comp** = ***OFF***
- **Calibration Method** = ***1-Point***
- **Background** = ***0***
- **Factor = 1**
- **Offset = 0**

▶ At the end, fill out the commissioning log, see *chapter 10*, *page 3-321* .

Tip

Always carry out a test calculation after every calibration. This will ensure that your calibration data are plausible and the detector is set correctly (see *chapter 2.36*, *page 3-229*, **Cps Average Mode** and **Cps Average Test**).

- This completes the calibration.

5.3 Calibration in the Cal Parameter Menu

Advanced functions

In addition to calibration with **Quick Start**, you can also calibrate using the **Cal Parameter** menu. Further options are offer there, such as:

- various types of calibration

- temperature compensation

You can enable additional signals and messages in the menu **Signal Condition**.

Via **I/O Setup** you can use existing or optional I/Os to output or process signals.

In order to avoid the risk that the device supplies faulty signals, it is imperative that you familiarize yourself with these additional features before you use them.

The calibration can be carried out as soon as the basic configuration has been set. Three types of calibration are possible:

- Two- or multi-point calibration
- One-point calibration
- Suspension calibration

5.3.1 Calibration Methods

The SENSseries LB 480 offers five calibration methods:

1. 1-POINT (one-point calibration)

   This type of calibration can be used in many applications. The absorption coefficient, the length of the absorption path and one calibration point are entered or measured. This calibration method should be used when

   – to keep a certain product density constant for the process during operation
   – when only one calibration point (value pair with count rate and density or concentration value) is available
   – to perform a pre-calibration only.

2. LINEAR (two- or multi-point calibration with linear coefficients)

   Linear curve fitting is the most frequently used calibration method.

   Here, the product density for two or more calibration points is measured or entered (two-point or multi-point calibration). This calibration method should be used when

   – accuracy is desired over the entire measuring range
   – only two calibration points are available.

   You should choose this calibration method also over a quadratic or cubic curve when

   – multiple calibration points are available, but these are very close together, so that not the entire range is covered by samples. Even minor errors in sampling or in the laboratory then distort the calibration curve significantly. It this case it may even be better to run only a one-point calibration.
   – sampling may be carried out only very inaccurately, so that the samples are subject to errors.

3. SQUARE (multi-point calibration with linear and quadratic coefficients)

   This type of calibration is used very rarely and requires visual assessment of the calibration points on y(x)-graph, as shown in *Fig. 5-1*.

   With this calibration method, the product density is measured or entered for at least three calibration points. This calibration method should be used only when

   – the entire measuring range is covered evenly with several calibration points
   – the measurement is carried out in % concentration, °Bx or another measured variable measurement, which is not in a linear relationship with the density.

4. CUBIC (multi-point calibration with linear, quadratic and cubic coefficients)

   This type of calibration is used only in exceptional cases and requires not only a thorough visual inspection of the calibration points on y(x)-graph, as shown in *Fig. 5-1*, but also a subsequent precise control of the measured value display using a test generator!

   With this calibration method, the product density is measured or entered for at least four calibration points. You should use this calibration method if a sufficient number of calibration points is available (approx. > 8), and the curve can clearly be fitted better to the calibration points with CUBIC than with LINEAR or SQUARE. We recommend to discuss the use of the calibration method CUBIC with BERTHOLD TECHNOLOGIES.

5. DIRECT ENTRY

   Direct entry means that you can enter an already known characteristic curve directly into the device, without requiring any calibration data or laboratory analysis data. The entry of the characteristic curve comprises the background, the absorption coefficient A1 and the measuring path.

   Direct entry of quadratic and cubic curves is not possible.

5.3.2 Operation Modes for Calibration

▶ If the Start menu is not already displayed, push **HOME** to go to the Start menu.

▶ Select **Device Config ▶ Setup ▶ Cal Parameter ▶ Cal Settings**.

▶ Select the calibration method under **Calibration Method**:
- ***DIRECT ENTRY*** for direct entry of a known calibration curve
- ***1-POINT*** for one-point calibration
- ***LINEAR*** for standard multi-point calibration
- ***SQUARE*** for a quadratic curve with at least 3 calibration points
- ***CUBIC*** for a cubic curve with at least 4 calibration points

• This completes the setting of the operating mode for the calibration.

5.4 Two and Multi-Point Calibration

Multi-point calibration can be based on a one-point calibration or started new. For calibration, several samples have to be taken and the product densities and concentrations are measured in the laboratory. The individual calibration points can be connected either by a straight line (two-point calibration) or by using multiple calibration points and calculating the characteristic curve using a linear, quadratic or cubic curve fit.

5.4.1 Basics

The gradient of the calibration curve can be determined accurately by two-point calibration. Multi-point calibration helps to exclude errors made during sampling and analysis. Furthermore, the output signal is in linear proportion to the concentration, even though the density is not linear to the concentration.

For multi-point calibration, measure the count rates obtained at different density values and enter the corresponding density or concentration value determined in the lab. You need not observe a rising or falling order when entering sample values.

IMPORTANT

However, correct correlation of measured count rate and density value from the lab measurement is important.

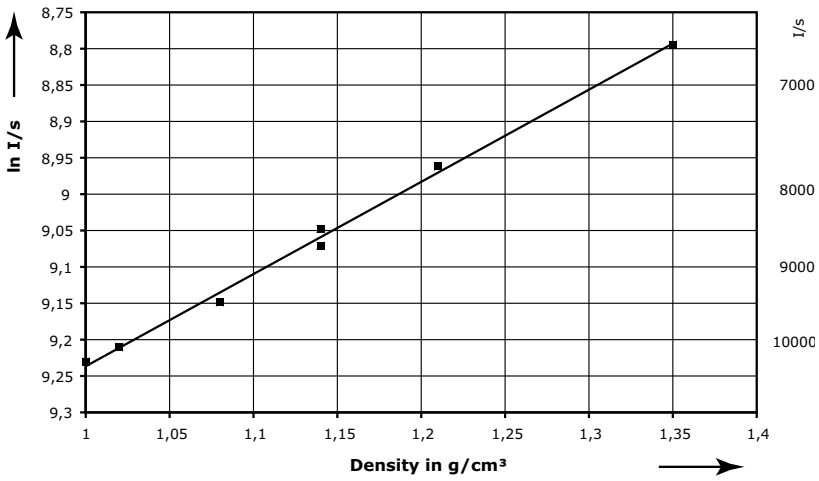


Fig. 5-1 Example of a multi-point calibration

The values have to be available in pairs. If the associated density or concentration value is missing, the count rate is automatically given the density or concentration value *0*. You can correct the data entered as often as needed, since the calibration process takes place only after selecting the menu item **CALIBRATE**. The following steps are carried out for a multi-point calibration:

1. Calculation of curve function

   The curve function is calculated using the selected calibration mode from the value pairs measured or entered in accordance with the lab values.

2. Calculation of square error of curve fit

   The quality of the calibration curve is calculated from the differences between the calculated calibration curve and the value pairs entered. Ideally, all points exactly match the calculated curve. The square error becomes zero.

3. Check of calibration curve for turning points

The system checks the curve for a clearly rising or falling trend. If this is not the case, the error message "Curve not clear" will be displayed.

5.4.2 Calibration

Linear two- or multi-point calibration is carried out in several steps:

1. Select operating mode ***LINEAR***.
2. Calibration at product density 1.
3. Calibration at product density 2.
4. Calibration at product density 3 and other product densities, if a multi-point calibration is performed.
5. Check calibration.

The individual steps are described in detail below. Further explanation of each function can be found in the parameter description in *Chapter 2*.

▶ If the Start menu is not already displayed, push HOME to go to the Start menu.

▶ Select **Device Config ▶ Setup ▶ Cal Parameter ▶ Cal Settings**

Cal Settings

▶ Under **Nuclides**, select the isotope of your source. If in doubt, see type plate on the shielding.

▶ Under **Calibration Method**, select ***LINEAR***.
If absolutely necessary, you may alternatively select ***SQUARE*** or **CUBIC**. For ***SQUARE*** at least 3 and for ***CUBIC*** at least 4 calibration points are required.

▶ Enter the measuring path in the product in **Measuring Path**.

Example: With a standard 90° measuring path on a pipe that would be the inner diameter of the pipe.

▶ Select the required unit in **Unit** to display your measured value. If you do not find the required unit in the selection list, you can switch with **Unit Family** to another unit family (***DENSITY 1***, ***2***, ***3***, or ***LENGTH***).
If the unit family ***SUSPENSION 1*** or ***2*** is required, enable the suspension measurement as described in *chapter 5.6*.

▶ Enter the lower measuring range in **Lower Range Limit**.

▶ Enter the upper measuring range in **Upper Range Limit**.

▶ Enter 180s in **ReadIn Time**. This defines the average time for reading-in the count rate of each calibration point.

▶ Go back to the menu **Cal Parameter**.

▶ Select **Product Conditions**.

Product Conditions

If the temperature compensation is needed, then proceed as described on *page 3-276*. In the other case, disable the temperature compensation:

▶ Under **Temp Compensation**, select ***OFF***.

▶ Go back to the menu **Cal Parameter**.

▶ Select **Cal Points**.

Cal Points

The background needs to be determined only when using a SuperSENS instead of a CrystalSENS. Proceed as follows to determine the background:

- Close the shielding with a filled pipe, or better dismantle the shielding from the fixture and put it down in a distance of at least 10m from the detector, so that no effective radiation arrives at the detector which may distort the background. See also chapter Background on *page 3-287*.
- Select **ReadIn *BACKGROUND***.
- Wait until the remaining time until the end of the operation has run down.

Record calibration points

- Under **Cal Point No.** select calibration point 1.
- Select **ReadIn *ACTIVE POINT***.
  This starts the reading-in of the count rates. While the count rate is read in, the average is calculated and displayed continuously.

  When reading-in the count rates, the time remaining up to the end of the operation is displayed. Finally, you are prompted to confirm the detected count rate with ***OK***. To shorten the read-in process, you can stop any time by pressing ***OK***.

  As you read in the count rate, or directly after this step, you also need to take a sample of the product in order to determine the density or the concentration in the laboratory. The sample must be representative, i.e.:
  - it must be taken in the immediate vicinity of the measuring point
  - it must be taken promptly after the reading-in of the count rate
  - the product density must not fluctuate during this period but must be constant

  Depending on the sampling site, it is best to let a sufficient amount initially run into another container before taking the actual sample. This prevents that a product located in a branch line may possibly distort the lab sample.

  Depending on the laboratory facilities, it is advisable to take duplicate samples and to have them analyzed in the lab at different times.
- Enter the density value of the sample analyzed in the laboratory in **Cal Density**.

Second calibration point

The density must be significantly higher or lower than that of the first calibration point.

- Under **Cal Point No.** select calibration point 2.
- Select **ReadIn *ACTIVE POINT***.
- Continue as with the first calibration point.

Additional calibration points

Each additional calibration point must clearly differ in its density from the previously recorded calibration points.

▶ Under **Cal Point No.** select the next free calibration point.

▶ Select **ReadIn *ACTIVE POINT***.

▶ Continue as with the first calibration point.

Tip

You can improve the quality of the calibration by distributing all recorded calibration points evenly over the entire measuring range. On the other hand, the calibration will be the worse the closer the density values ??of the individual calibration points lie next to each another.

Tip

Under **Cal Points ▶ Calibration Chart** you can view, edit or delete the calibration table.

▶ Go back to the menu **Cal Parameter**.

▶ Select **Calibrate** and press ***OK***.

• This completes the multi-point calibration.

Checking a multi-point calibration

The absorption coefficients and thus the curve function can be calculated based on the entered value pairs. The square error indicates how well the calculated curve could be approximated to the entered or measured values. However, you cannot use the square error as a criterion for the selection of a particular waveform (quadratic, cubic). View the following data in the menu **Meas Data** and in the menu **Reading Range** and if you find any deviations check the calibration:

Display	Value	
Meas Coefficient A2	calculated coefficient (with calibration method LINEAR = 0)	
Meas Coefficient A2	calculated coefficient (with calibration method LINEAR + SQUARE = 0)	
Factor	1	
Offset	0	
Square Error	<0.0005	very good calibration
	<0.0019	good calibration
	<0,002	still usable

We get a **Square Error** unequal to zero only when at least one calibration point more is available than is required as a minimum.

Tip

Always carry out a test calculation after every calibration. This will ensure that your calibration data are plausible and the device is set up correctly (see *chapter 2.35* **Cps Average Mode** and **Cps Average Test**).

5.5 One-Point Calibration

The one-point calibration has already been explained in the **Quick Start** section. It is also accessible on **Cal Parameter** and can there be combined with other functions, such as the temperature compensation.

One-point calibration is used when a calibration is possible with only one density value.

5.5.1 Basics

For one-point calibration you must enter or measure a value pair (count rate and density or concentration value), the absorption coefficient and the absorption path length. You can take the absorption coefficient for the current products from the table below.

For products not listed in this table, enter the following values for the unit g/cm^3.

Cs-137

	Frontal (axial) irradiation	Lateral irradiation
Absorption coefficient µ	-0.0664	-0,057

Co-60

	Frontal (axial) irradiation	Lateral irradiation
Absorption coefficient µ	-0.0478	-0.0403

For other units, and if you are not using the unit family ***SUSPENSION***, you have to convert the absorption coefficients:

$$\mu_x = \mu \cdot \frac{\Delta\rho}{\Delta C} = \mu \cdot \frac{\rho_{max} - \rho_{min}}{C_{max} - C_{min}}$$

Example

ρ_{max} = 0.95 g/cm^3 : $C_{\rho max}$ = 30 %

ρ_{min} = 0.91 g/cm^3 : $C_{\rho min}$ = 50 %

$$\mu_x = -0.0664 \cdot \frac{0.95 - 0.91}{30 - 50} = 0.000133$$

In this case, enter *1.33e-04*.

Influence of a faulty absorption coefficient

The curve obtained with one-point calibration always passes through the calibration point. The gradient of the curve is determined by the entered absorption coefficient and may therefore be somewhat inaccurate. *Fig. 5-2* illustrates how an accurate coefficient can affect the calibration. Assuming that the characteristic curve a) shows the correct course of the characteristic curve, the characteristic curves b) and c) show how the characteristic curve changes when the entered coefficient is too large or too small.

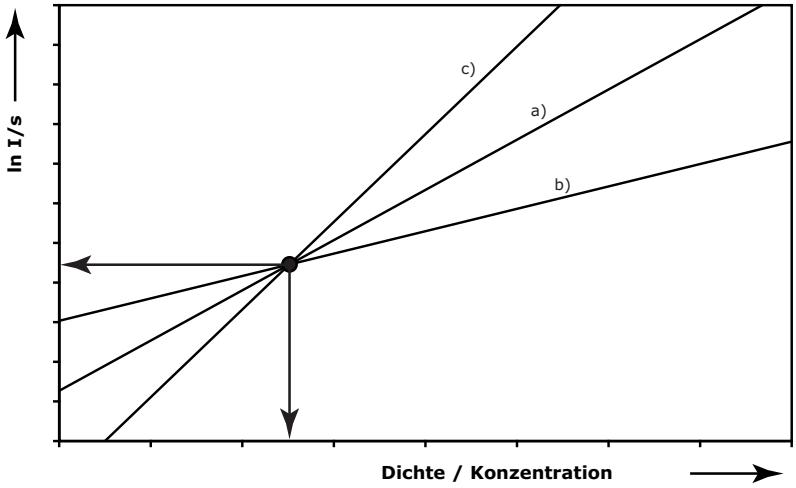


Fig. 5-2 Influence of the absorption coefficient

An error in the calibration can have a more important effect, the more the measured value deviates from the calibration point.

You may later add further calibration points to improve the calibration.

5.5.2 Calibration

One-point calibration is performed in five steps:

1. Select operating mode one-point calibration.
2. Enter the absorption coefficient
3. Enter length of the absorption path
4. Record calibration point
5. Check calibration

The individual steps are described in detail below.

Prerequisite for one-point calibration:

- the current density or concentration is at a normal value, or in the middle measuring range.
- the absorption coefficient is known.

▶ If the Start menu is not already displayed, push HOME to go to the Start menu.

▶ Select **Device Config ▶ Setup ▶ Cal Parameter ▶ Cal Settings**

Cal Settings

▶ Under **Nuclides**, select the isotope of your source. If in doubt, see type plate on the shielding.

▶ Under **Calibration Method**, select ***1-POINT***.

▶ Enter the measuring path in the product in **Measuring Path**.

Example: With a standard 90° measuring path on a pipe that would be the inner diameter of the pipe.

(pay attention that your entries are accurate to the millimeter)

▶ Select the required unit in **Unit** to display your measured value. If you do not find the required unit in the selection list, you can switch with Unit Family to another unit family (***DENSITY 1***, ***2***, ***3***, or ***LENGTH***).
If the unit family ***SUSPENSION 1*** or ***2*** is required, enable the suspension measurement as described in *chapter 5.6*.

▶ Enter the lower measuring range in **Lower Range Limit**.

▶ Enter the upper measuring range in **Upper Range Limit**.

▶ Enter 180s in **ReadIn Time**. This defines the average time for reading-in the count rate of each calibration point.

▶ Go back to the menu **Cal Parameter**.

▶ Select **Product Conditions**.

Product Conditions

If the temperature compensation is needed, then proceed as described on *page 3-276*. In the other case, disable the temperature compensation:

- Under **Temp Compensation**, select ***OFF***.
- Go back to the menu **Cal Parameter**.
- Select **Cal Points**.

Cal Points

The background needs to be determined only when using a SuperSENS instead of a CrystalSENS. Proceed as follows to determine the background:

- Close the shielding with a filled pipe, or better dismantle the shielding from the fixture and put it down in a distance of at least 10m from the detector, so that no effective radiation arrives at the detector which may distort the background. See also chapter Background on *page 3-287*.
- Select **ReadIn *BACKGROUND***.
- Wait until the remaining time until the end of the operation has run down.

Record calibration point

- Under **Cal Point No.** select calibration point 1.
- Select **ReadIn *ACTIVE POINT***.
  This starts the reading-in of the count rates. While the count rate is read in, the average is calculated and displayed continuously.

  When reading-in the count rates, the time remaining up to the end of the operation is displayed. Finally, you are prompted to confirm the detected count rate with ***OK***. To shorten the read-in process, you can stop any time by pressing ***OK***.

  As you read in the count rate, or directly after this step, you also need to take a sample of the product in order to determine the density or the concentration in the laboratory. The sample must be representative, i.e.:
  - it must be taken in the immediate vicinity of the measuring point
  - it must be taken promptly after the reading-in of the count rate
  - the product density must not fluctuate during this period but must be constant

  Depending on the sampling site, it is best to let a sufficient amount initially run into another container before taking the actual sample. This prevents that a product located in a branch line may possibly distort the lab sample.

  Depending on the laboratory facilities, it is advisable to take duplicate samples and to have them analyzed in the lab at different times.

▶ Enter the density value of the sample analyzed in the laboratory in **Cal Density**.

▶ Under **Cal Coefficient A1**, enter the absorption coefficient as described in *chapter 5.5.1*.

Tip
Under **Cal Points ▶ Calibration Chart** you can view, edit or delete the calibration table.

▶ Go back to the menu **Cal Parameter**.

▶ Select **Calibrate** and press ***OK***.

• This completes the one-point calibration.

Checking a one-point calibration

The entered absorption coefficient must be unchanged. Also view the following information and if you detect any deviations check the calibration:

Display	Value
Meas Coefficient A2	0
Meas Coefficient A3	0
Factor	1
Offset	0
Square Error	0

Tip
Always carry out a test calculation after every calibration. This will ensure that your calibration data are plausible and the device is set up correctly (see chapter *2.35* **Cps Average Mode** and **Cps Average Test**).

5.6 Enabling the Suspension Measurement

A suspension measurement is used to determine the amount of the solid in a mixture. If the measured value is determined, for example, in weight per volume, then a measured value of 200 g/L means that one liter of mixture contains 200g solid. If the measured value is displayed in weight percent, then a measured value of 10% means that in 100% of the mass of a mixture there is a share of 10% of solid mass.

The suspension measurement has to be enabled when:

- the measured value is to be output as the concentration
- the concentration differences result from the ratio of maximum two components
- the two components are known and have constant densities

If the suspension measurement is to be used, it must be enabled before recording the calibration points.

For more information on suspension measurements see *chapter 7.3*.

▶ If the Start menu is not already displayed, push HOME to go to the Start menu.

▶ Select **Device Config ▶ Setup ▶ Cal Parameter ▶ Cal Settings**

Cal Settings

▶ In **Unit Family** select ***SUSPENSION 1*** (g/L, g/cm3, ...), or ***SUSPENSION 2*** (Brix, % sol-wt)

▶ Select the required unit in **Unit** to display your measured value.

▶ Go back to the menu **Cal Parameter**.

▶ Select **Product Conditions**.

Product Conditions

▶ In **Liquid Density**, enter the value of the liquid density in g/cm3.

▶ In **Solid Density**, enter the value of the solids density in g/cm3.

- The suspension measurement is enabled.

5.7 Temperature Compensation

Temperature fluctuations in the product to be measured are usually associated with density fluctuations. This means that a changed density value is displayed, although the concentration of the product has not changed. To avoid this, you can use the temperature compensation.

If the temperature measurement is to be used, it must be enabled before recording the calibration points.

Temperature measurement

The product temperature is measured by a Pt100 resistance thermometer that is mounted by the customer on the pipe in close proximity to the measurement site.

The Pt100 has to be connected to terminal 15 and 16.

While the count rate for the calibration point is being read in, the temperature is also read in automatically.

Monitoring the temperature signal

If the temperature compensation is enabled, the temperature signal is monitored and an error message is output:

- Pt100, at >180°C, e.g. if no Pt100 is connected
- Pt100, at <-30°C, e.g. if the Pt100 input is short-circuited

For the error messages to be triggered correctly:

- the tolerance of the compensating resistor must not exceed 1%.
- the line resistance must not exceed 8 Ω.

Reference temperature

Linear temperature coefficient (TK_1):

The average product temperature (not the lab temperature) is entered as reference temperature. A correction value (ϑ_ρ - ϑ_{Ref}) * TK_1 is added to the measured value. A slightly incorrectly entered value TC_1 will then have a more significant effect, the larger the difference ϑ_ρ- ϑ_{Ref}.

If you assign the density values determined at a constant lab temperature to the count rate read in at operating temperature, the display is always equal to the density value calculated relative to the lab temperature.

Example: If the temperature varies over the year between 10 and 30°C, then you have to enter a temperature of 20°C.

Square temperature coefficient (TC_1 and TC_2):

The lowest temperature used for the calculation of the temperature coefficients is entered as the reference temperature.

Example: If the temperature varies over the year between 10 and 30°C, then you have to enter a temperature of 10°C.

Enabling the standard temperature compensation

▶ If the Start menu is not already displayed, push HOME to go to the Start menu.

▶ Select **Device Config ▶ Setup ▶ Cal Parameter ▶ Product Conditions**

▶ Under **Temp Compensation**, select ***STANDARD TC***.

▶ Under **Temp. Unit**, select the unit for the temperature (***degC*** or ***degF***).

▶ Enter the reference temperature in **Ref Temp**.

▶ In **TC 1**, enter the linear temperature coefficient (see *chapter 7.5*).

▶ If required, in **TC 2**, enter the square temperature coefficient (see *chapter 7.5*).

• The standard temperature compensation is enabled.

Enabling the water temperature compensation

The temperature characteristic of water is already stored for suspension measurements using water as a carrier liquid. Therefore, no data has to be entered for the temperature coefficient and the reference temperature.

▶ If the Start menu is not already displayed, push HOME to go to the Start menu.

▶ Select **Device Config ▶ Setup ▶ Cal Parameter ▶ Cal Settings**

▶ Under **Temp Compensation**, select ***WATER TC***.

▶ Under **Temp. Unit**, select the unit for the temperature (***degC*** or ***degF***).

• The water temperature compensation is enabled.

5.7.1 Correction of the Lab Values

The count rates measured during the calibration are dependent on the density of the product during the measurement. The density of the sample is usually determined in the laboratory at a fixed temperature. With constant concentrations but different temperature between the count rate measurement and the measurement in the laboratory we would then get incorrect characteristic values. To avoid such calibration errors, the product temperature is also stored in the SENSseries LB 480 when measuring. When calculating the calibration curve, the entered laboratory value is corrected by means of the temperature coefficient.

This correction is carried out only when:

– Temp Compensation is specified in the device configuration (see *chapter 2.22* on *page 3-216*)

– at least one temperature coefficient is entered (see *chapter 2.22* on *page 3-217*).

The corrected lab values from which the calibration curve is calculated are displayed after the coefficients and the square error, provided the temperature compensation was enabled during calibration. Otherwise, the lab value already entered is displayed.

For concentration measurements the temperature compensation always has to be enabled prior to performing calibration. The following section is relevant only for density measurements:

– No correction is required if the density has been determined at exactly the same temperature at which the count rate was read in (e.g. spindles on site). Enter the density value directly and enable the temperature compensation only after the calibration.

– Manual correction of the sample values ??is required only if the measurement was run in g/cm^3, and the density of the samples was determined in the laboratory at various temperatures. Carry out the following corrections:

$$\rho_K = \rho_M - (\vartheta_\rho - \vartheta_M) \cdot TC_1$$

ρ_K	=	corrected input value
ρ_M	=	measured density value
ϑ_ρ	=	product temperature during the density measurement
ϑ_M	=	reference temperature relative to which the density was calculated
TK_1	=	Temperature coefficient

The display always relates to ρ_M.

Example with manual correction

Temperature coefficient = $0.5*10^{-3}$

ρ_M in g/cm^3	ϑ_ρ in °C	ϑ_M in °C	ρ_K in g/cm^3
1.30	75	70	1.2975
1.32	70	70	1.3200
1.35	65	70	1.3750

Since in this case correction has already been done manually, the temperature compensation must be turned off and then on again.

5.8 Correction of the Measured Values

Addition and multiplication functions are available for the correction of the measured values?. However, these are no substitute for a careful calibration; they should only be used for minor corrections. Otherwise we recommend doing a re-calibration.

5.8.1 Correction with Factor and Offset

- If the Start menu is not already displayed, push HOME to go to the Start menu.
- Select **Device Config ▶ Setup ▶ Signal Condition ▶ Reading Range**
- In **Factor**, enter the value for the multiplicative factor.
- In **Offset**, enter the value for the additive constant.
- Then check if your measured value is output properly corrected.

Additive constant

The value stored under Offset is added to the density value calculated on the basis of the count rate. This allows a parallel shift of the calibration curve.

Example additive constant:

Measuring range 1.1 – 1.3g/cm^3

It is found that the measuring values are too low by 0.05g/cm^3.

Remedy: Enter *0.05* at Offset. All measured values will be raised by 0.05g/cm^3, i.e. instead of 1.1g/cm^3 1.15g/cm^3 is now displayed and instead of 1.3g/cm^3 1.35g/cm^3 is displayed.

If the measured values are too high by 0.05g/cm^3, you have to enter *-0.05*.

Multiplicative factor

Each measured value is multiplied by the value specified in **FACTOR**. This allows you to change the gradient of the calibration curve.

Example multiplicative factor:

Measuring range 1.1 –1.3g/cm^3

If you enter 1.1 at Factor, 1.21g/cm^3 will be displayed instead of 1.1g/cm^3. Instead of 1.3g/cm^3, the value 1.43g/cm^3 is now displayed.

Correction with Factor and Offset

When using a multiplicative factor only, however, the lower point of the measuring range is increased as well, provided it is not at 0. For this reason, the Factor may normally not be used alone for the correction, but must be calculated in combination with the Offset. It is

necessary to determine the ACTUAL and TARGET values at two points each. The two points should be fairly far away from each other so that the curve is corrected as accurately as possible.

The formula used for the automatic correction is:

$A_k = A_i \times F + K$

A_k: corrected measured value

A_i:current measured value

F: Factor

K: Offset

Two examples for the calculation of Factor and Offset.

Example 1:

At 1.1g/cm^3 the displayed value is correct, instead of 1.2g/cm^3, however, 1.25g/cm^3 should be displayed.

Calculation of the Factor:

$$F = \frac{H_{soll} - L_{soll}}{H_{ist} - L_{ist}} = \frac{1.25 - 1.1}{1.2 - 1.1} = 1.5$$

Calculation of the Offset:

$$K = L_{soll} - (L_{ist} \cdot F) = 1.1 - (1.1 \cdot 1.5) = -0.55$$

with

H_{actual}	=	upper display value
H_{target}	=	Lab value of the density when H_{actual} is displayed
L_{actual}	=	lower display value
L_{target}	=	Lab value of the density when L_{actual} is displayed

Example 2:

$L_{actual} = 1.12 g/cm^3$

$L_{target} = 1.15 g/cm^3$

$H_{actual} = 1.25 g/cm^3$

$H_{target} = 1.3 g/cm^3$

This results in:

$$F = \frac{H_{soll} - L_{soll}}{H_{ist} - L_{ist}} = \frac{1.3 - 1.15}{1.25 - 1.12} = 1.1538$$

and

$$K = L_{soll} - (L_{ist} \cdot F) = 1.15 - (1.12 \cdot 1.1538)$$
$$= -0.1423$$

Enabling Factor and Offset

▶ If the Start menu is not already displayed, push HOME to go to the Start menu.

▶ Select **Device Config ▶ Setup ▶ Signal Condition ▶ Reading Range**

▶ In **Factor**, enter the value for the multiplicative factor.

▶ In **Offset**, enter the value for the additive constant.

• Factor and offset are now enabled.

▶ Then check if your measured value is output properly corrected.

Please note that after each calibration with **Calibrate**, **Factor** and **Offset** will be reset automatically.

To disable factor and offset manually:

▶ In **Factor**, enter the value ***1***.

▶ In **Offset**, enter the value ***0***.

6

Functional Processes

The following chapter describes the major functional processes that occur when working with the SENSseries.

6.1 Plateau Measurement

Below we will describe how to perform a plateau measurement. The plateau measurement checks the function of the detector.

IMPORTANT

The radiation conditions must be constant while recording the plateau!

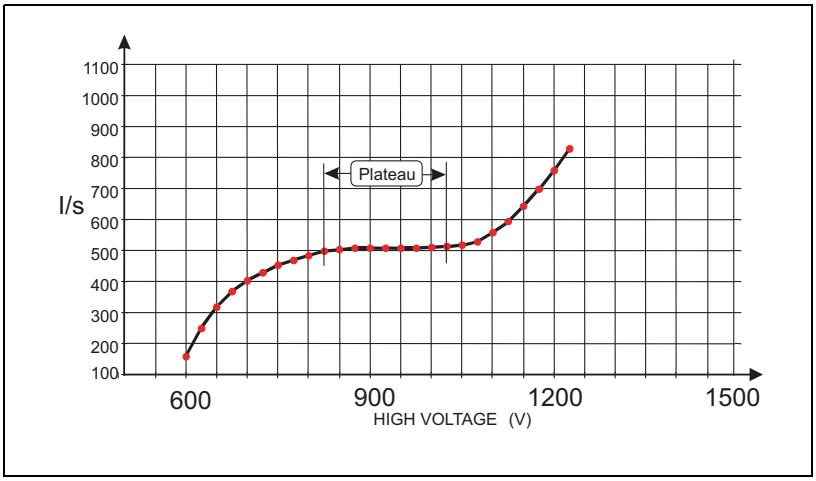


Bild 6-1 Result of a plateau measurement

The plateau is the flat section of the curve and it is typically approx. 200V long (see also Volume 2, *chapter 4.5*). Please note that the above characteristic curve and the following information is only valid for a NaI detector. With a plastic scintillator the plateau is steeper and may have to be qualified by a BERTHOLD service technician.

3

The crystal-multiplier assembly or the complete detector has to be replaced if:

- the plateau is shorter than 50V
- the count rate changes by more than 5% per 100 Volt high voltage

IMPORTANT

During the plateau measurement the density measurement is held at the last measured value.

If the Start menu is not already displayed, push ***HOME*** to go to the Start menu.

▶ Select **Device Config ▶ Setup ▶ Service ▶ Plateau ▶ Plateau Measurement**.

▶ At **HV Start** enter the high voltage (e.g. 500V, minimal 300V), where the plateau measurement should start and confirm the input with ***ENTER***.

▶ At **HV Stop** enter the high voltage (1000V, maximal 1300V), where the plateau measurement should stop and confirm the input with ***ENTER***.

▶ At **HV Step** enter the step size between the measurement points (e.g. 50V) and confirm by pressing ***ENTER***.

The step width determines the number of value pairs. The larger the step width, the lower the number of the value pairs!

▶ At **Meas. Time** enter the time how long a measurement point should be recorded or the count rate is to be averaged (e.g. 20 s) and confirm the entry with ***ENTER***.

▶ Transfer the entries with ***SEND***.

▶ Select ***PLATEAU*** at **HV Mode** to start the plateau measurement.

The plateau measurement is started. For this purpose, the measuring mode is exited and the plateau of the multiplier which is used in the detector is measured.

During the plateau measurement the values of the following parameters are updated continuously:

- **HV Live**: HV value of the voltage at which the count rate is being measured.
- **Cps Single Detector:** Count rate of the selected detector.
- **Cps Live**: Total count rate of all detectors.

At the end of the plateau measurement the detector automatically switches back to **HV Mode**: ***AUTO*** or ***MANUAL***, depending on which mode was last set.

The plateau measurement is now complete and can be viewed and reviewed under **Plateau View** as a table or plateau curve.

6.2 Master Reset

Besides the options described in **Device Config ▶ Setup ▶ Service ▶ Reset Device** on *page 3-227* to reset the detector or certain functions, there is the *Master Reset*, which deletes *all* parameters. You have to open the housing to perform the Master Reset.

IMPORTANT

Perform a Master Reset only if a previous ***SW Reset*** *or even a* ***Factory Reset*** *was not successful.*

Please keep in mind that after a ***Master Reset****:*
– the previously set parameters will be lost
– the license key must be entered again
– current output and HV default have to be adjusted
– the measurement needs to be calibrated

If in doubt, have this work carried out by the BERTHOLD TECHNOLOGIES service.

WARNING

EX

Risk of explosion!

For detectors that are used in hazardous areas, the housing must only be replaced by the BERTHOLD TECHNOLOGIES service or by persons authorized by BERTHOLD TECHNOLOGIES. If this is not possible, you must replace the entire detector or return it to the manufacturer for repair.

For non-Ex devices, you can proceed as described below.

Preparing for Master Reset

You will need:

– M5 and M8 Allen wrenches to open the housing.
– Jumpers to bridge two pins.
– Your original license key from your code listing or from the Service menu.
– Multimeter to adjust the current output.
– The current value for **HV Default** (*chapter 2.14*, *page 3-200*).
– Clean working environment, so that no debris or dirt can get into the electronics.

WARNING

Risk of fatal injury due to electric shock!

If the housing is open you may come into contact with live parts if the power supply is connected.

The Master Reset has to be carried out with open housing cover and the power supply turned on. Power supply is applied to the terminals 1 to 4.

Furthermore, high voltage is present in the area of the base of the board for the photomultiplier.

Perform Master Reset

1. Disconnect detector from mains.
2. Open housing.
3. Plug bridge on connector "F" (the connector is located on the CPU board next to the large capacitor).
4. Turn detector on and wait 10 seconds until the LED flashes.
5. Turn detector off again.
6. Pull bridge off connector "F".
7. Turn detector on and wait 10 seconds until the LED flashes.
8. Turn detector off again.
9. Connect HART® Communicator to the current output in the terminal compartment.
10. Turn detector on again and wait 10 seconds until the LED flashes.
11. Acknowledge error message on HART® Communicator.
12. Enter License Key new, menu **Device Config ▶ Setup ▶ Service ▶ License Key**, see *chapter 2.32*, *page 3-227*.
13. Adjust current output with multimeter, menu **Device Config ▶ Setup ▶ I/O Setup ▶ Current Out ▶ D/A trim**, see *chapter 2.25*, *page 3-219*.

IMPORTANT
The adjustment is absolutely essential, even if the current output appears to be OK.

14. Enable monitoring of the 4-20 mA current signal (set to ***ENABLED***), menu **Device Config ▶ Setup ▶ I/O Setup ▶ Current Out ▶ Current Loop Monitoring**
15. Set Detector Code, menu **Device Config ▶ Setup ▶ Sensor Configuration ▶ Sensor Settings ▶ Detector Code**, *see page 2-92.*
16. Set **HV Default**, see *chapter 5.1.2*, *page 3-254*.

This completes the reset, the detector is now ready for calibration.

7

Explanations

7.1 Background

The term "background" refers to the count rate resulting from the natural environmental radiation. The background level is largely dependent on the scintillator volume. The background is not accounted for by the decay compensation as it is regarded as a constant.

An error when recording the background may later lead to drift effects in the measurement. Influences from neighboring radiation sources must be avoided.

The background has to be recorded only for the SuperSENS. The background need not be recorded for the CrystalSENS.

To measure the background, the shielding with the source must not be mounted and must be at least 20 m away from the measuring point. If the shielding is dismantled for this purpose, it must first be closed.

The background should always be measured with a filled product line, or a filled container.

7.2 Radiation Interference Detection

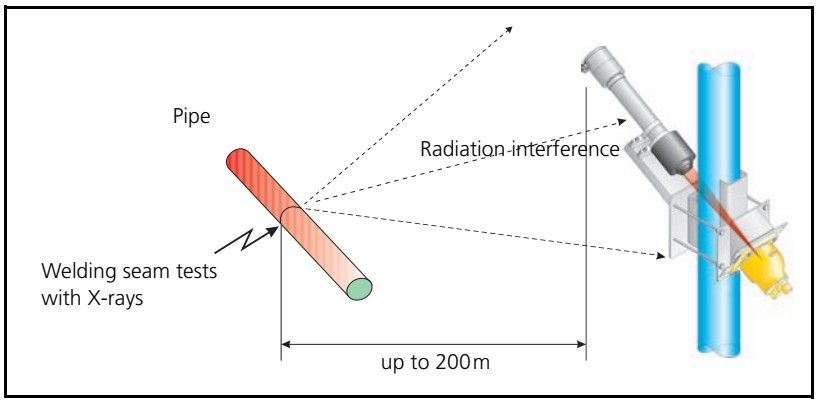


Fig. 7-1 Radiation interference

7.2.1 Detecting Interference Radiation

The high Gamma sensitivity of scintillation detectors may cause a false reading. To detect interfering radiation, a double plausibility check can be enabled.

The alarm is triggered by:

Scenario A:

Maximum possible count rate (empty calibration)

Is > Io * 1.5

Is = current count rate in cps integrated over one second
Io = maximum count rate at empty calibration

Scenario B:

Mean value of current count rate monitored.

The system sensitivity, i.e. the distance of the alarm thresholds is defined as the multiple of the mean statistical variations and can be entered as Sigma value as needed. The time constant is one second.

When reaching the alarm threshold, a message is output via the error relay and on the device display.

Is > Im + n * Sigma

Im = current count rate integrated over one second

n = multiple value of Sigma

Further information on scenario A:

A relative limit value is monitored, i.e. the alarm threshold is reached when exceeding a maximum dose rate (calibration value at empty vessel) at the detector.

False alarms due to operative factors are not possible. However, only stronger interfering radiation is detected.

Further information on scenario B:

A differential limit value is monitored, i.e. each fast rise of the dose rate triggers an alarm.

Even minor outside radiation is detected, when it occurs erratically. Operative factors such as fast emptying of the vessel or opening the shielding container may trigger false alarms.

To rule out false alarms with sufficient statistical safety, you should enter n > 5. The mathematical correlation shows that the distance of the alarm threshold is dependent upon the respective mean count rate In.

For calculation it holds:

$$\text{Sigma} = \sqrt{\text{cps}}$$

Example

Count rate Im = 300 cps, n = 6

$$Is = Im + n \times \sqrt{In}$$

$$Is = 300 + 6 \times \sqrt{300} = 404 \text{ cps}$$

Thus, an alarm is signaled as soon as Is exceeds 404 cps.

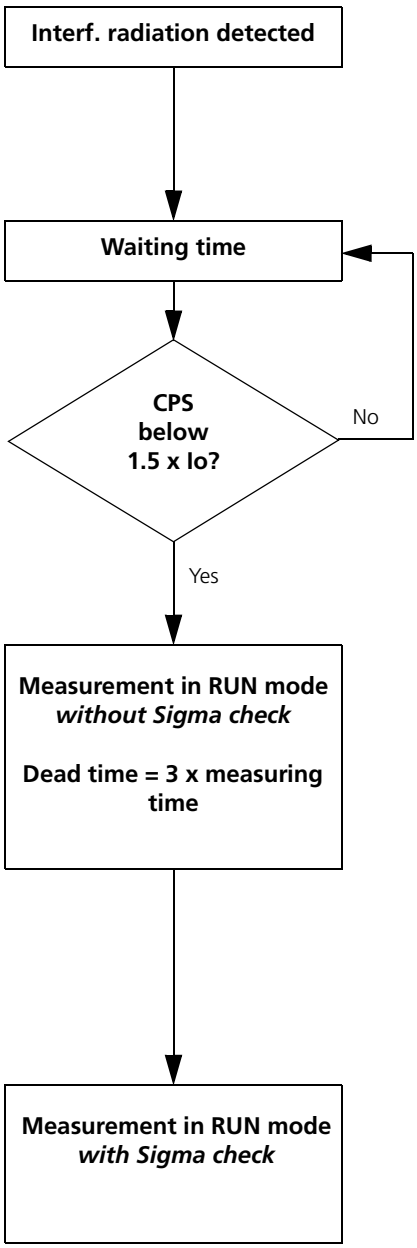
IMPORTANT

Due to the dynamic behavior of the interference radiation detection, a quick increase of the pulse rate due to operational factors (e.g. empty running pipeline) can be interpreted as interfering radiation. By setting the parameters for the interference radiation detection accordingly, erroneous activation by these operating conditions can be suppressed. However, the radiation interference detection also becomes less sensitive.

For example, opening the useful beam channel on the shielding can also cause a quick increase of the count rate. You have to reset the alarm that is then triggered, or better, do not enable the interfering radiation detection at first. However, it would be better not to enable the interfering radiation detection at first. Enable the interfering radiation detection only after calibration.

7.2.2 Interference Radiation Detection Flow Chart

If radiation interference is detected, following will happen:



If interference radiation is detected, the measurement switches to the HALT mode.

- Measured value and current output are "held".
- Error relay indicates alarm.

The measurement is "held" up to the end of the defined waiting time.

At the end of the waiting time the system checks if the arriving count rate is smaller than 1.5-times the calibrated empty count rate (Io) (see scenario A). If not, the waiting time starts again.

If the count rate is below 1.5-times the empty count rate, the measurement automatically switches to the RUN mode. Sigma detection (see scenario B) is disabled for 3 x measuring time (= dead time).

Example:

If the measurement time is 20s, the dead time is 60s. This time is needed for the measurement to adjust to a possibly changed density, without triggering interference radiation detection. During this time, interference radiation is detected only when the count rate has increased to 1.5-times the empty count rate.

At the end of the dead time the Sigma detection is active again.

7.3 Measurement of Suspensions

Clear correlation of density and concentration is possible only when

- liquid density

  and

- solid density

are constant.

Concentration measurements of suspensions can be carried out in these units:

1. Concentration in weight per volume (g/L, g/cm^3, kg/m^3, ...)
2. Concentration in degBrix
3. Concentration in percent by weight (% sol-wt)
4. °Be

Data input, calibration and display are carried out in the selected unit of measure. The calibration curve, however, is calculated in g/cm^3 i.e. for the units in items 1 to 4 the values ??are internally converted into g/cm^3 in order to detect the curvature of the characteristic curve. Through conversion, a correct characteristic line can be obtained for suspensions already with one or two calibration points.

For the conversion, both the solid density and the liquid density can be entered. If you do not know the solid density, you can determine it as follows:

1. Determine the weight of the dry solid
2. Determine the volume, e.g. by displacement of water
3. Dividing weight by volume in the unit g/cm^3

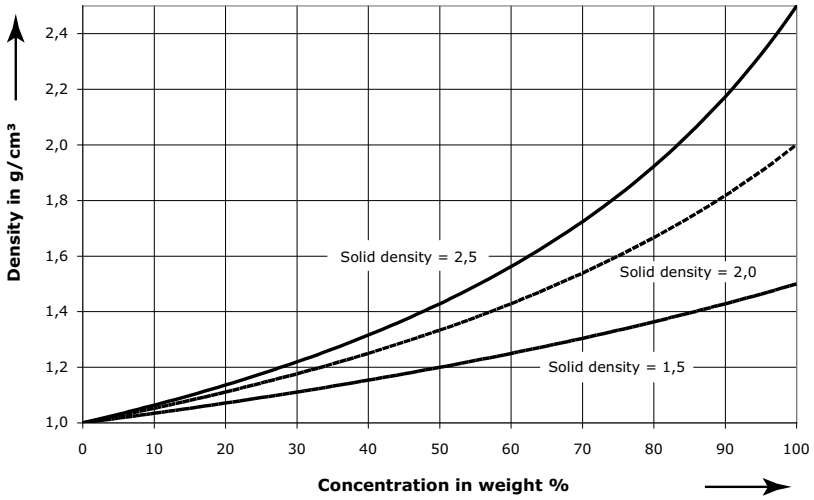


Fig. 7-2 Density of suspensions

The conversion is carried out according to the formulas.

Conversion concentrations in g / l

$$\rho = \left(1 - \frac{S}{\rho_S \cdot 1000}\right) \cdot \rho_L + \frac{S}{1000}$$

ρ = density of suspension g/cm^3

ρ_S = solids density in g/cm^3

S = solids content in g/l

P_L = liquid density in g/cm^3

Conversion concentrations in %

$$\rho = \rho \cdot \frac{\rho_L}{\frac{C' \cdot \rho_L}{\rho_S} + 1 - C'} = \frac{\rho_L \cdot \rho_S}{C' \cdot (\rho_L - \rho_S) + \rho_S}$$

ρ = density of suspension g/cm^3

ρ_S = solids density in g/cm^3

S = solids content in g/l

P_L = liquid density in g/cm^3

C' = concentration in percentage by weight/100

Conversion concentrations in ° Be

For $\rho < 1$:

$$\rho = \frac{144.3}{144.3 - n}$$

For $\rho > 1$:

$$\rho = \frac{144.3}{144.3 + n}$$

n = °Be

Strictly speaking, the formulas for g/l and concentration in % apply only to suspensions. For solutions or liquid mixtures, large deviations may occur when the measurement involves larger ranges.

The diagram in *Fig. 7-3* shows how to convert the units for calibration.

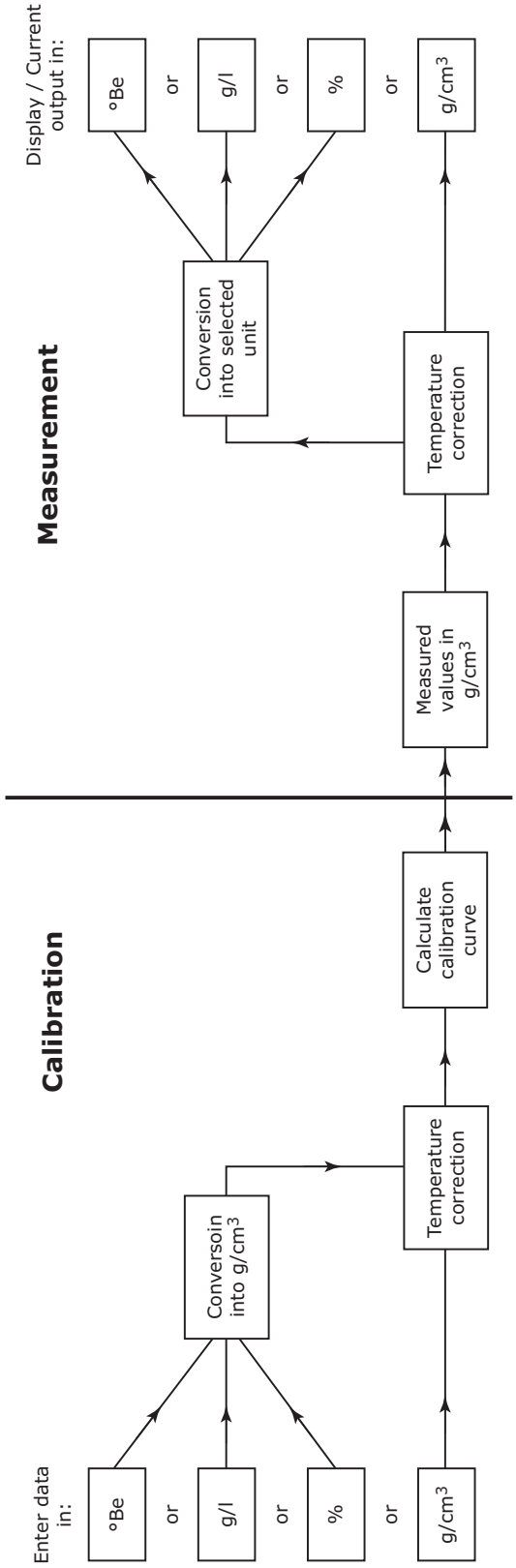


Fig. 7-3 Calculation of suspensions

7.3.1 Calculating the Density of Individual Components

With suspensions one can usually assume that liquid and solid density are constant. This is not the case when the liquid contains dissolved substances in different concentrations.

With solutions, one can use the suspension formula to allow simple calibration. However, it is better to use multi-point calibration without the suspension formulas since with solutions the density of both components is not constant due to the mixing ratio. With suspensions the solid density is usually known and water can be used as carrier liquid; with solutions, on the other hand, the density of the relevant components has to be calculated from table values.

Enter the density of the carrier liquid or the density of the attendant component (mostly water) at average temperature (reference temperature) as liquid density.

Table values are available as % concentration/density

In this case:

$$\rho_S = \frac{C' \cdot \rho_L}{\frac{\rho_L}{\rho} - 1 + C'}$$

ρ = density of the mixture in g/cm^3 at medium concentration

ρ_S = density of the component to be measured (solid density)

P_L = density of the attendant component (liquid density) in g/cm^3

C' = concentration in percentage by weight/100

Example

Product	HCl – H_2O
Measuring range: Concentration	10 ... 30 % HCl
Average product temperature	20°C
Density ρ at 20°C and 20 % concentration	1.0980 g/cm^3
Density H_2O (ρ_L) at 20°C	0.99823 g/cm^3

$$\rho_S = \frac{0.2 \cdot 0.99823}{\frac{0.99823}{1.0980} - 1 + 0.2} = 1.8294$$

Input liquid density	0.99823
Input solid density	1.8294

Table values of the example are available as concentration in g/l

In this case:

$$\rho_S = \frac{S \cdot \rho_L}{\rho_L - \rho + S}$$

ρ = density of the mixture in g/cm^3 at medium concentration

ρ_S = density of the component to be measured (solid density)

P_L = density of the attendant component (liquid density) in g/cm^3

S = concentration in g/l/1000

Example

Concentration	219.6 g/l
Concentration S	0.2196
Density ρ	1.0980 g/cm^3
Density H_2O (ρ_L)	0.99823 g/cm^3

$$\rho_S = \frac{0.2196 \cdot 0.99823}{0.99823 - 1.0980 + 0.2196} = 1.8294$$

Input liquid density	0.99823
Input solid density	1.8294

7.4 Time Constant

The time constant is calculated automatically (default), but can also be set manually to a fixed value. The time constant smoothes the output signal. Statistical fluctuations as well as process-related fluctuations in density, e.g. caused by agitators, can be smoothed.

The measured data supplied by the detector is averaged with the time constant.

A so-called RC-averaging is carried out:

nM = aM + ((AZR - aM) * (1 - e(-t/τ)

nM = new mean value

aM = old mean value

AZR = current, non-averaged count rate
(current display count rate)

t = time interval between the measurements in seconds

τ = time constant in seconds

Fig. 7-4 shows the reaction of the output signal in case of erratic filling of the container (input change) from 0 to 100 %.

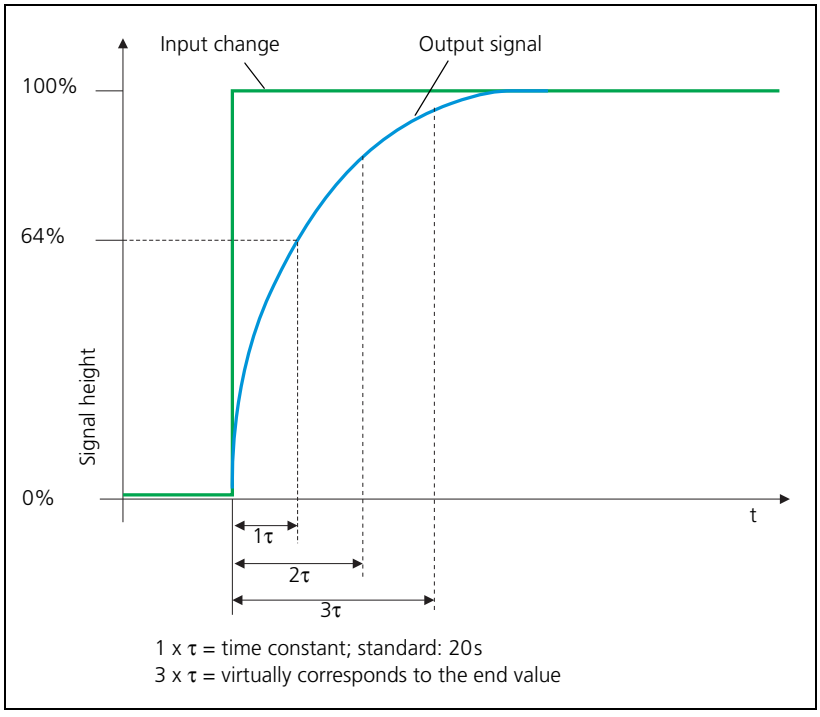


Fig. 7-4 Time constant

7.5 Temperature Compensation

Function of temperature compensation

The temperature coefficient of a liquid is not constant over a large temperature range, but usually it increases with rising temperatures. Temperature compensation is carried out according to the following formula:

$$\rho_{Ref} = \rho_M + (\vartheta_\rho - \vartheta_{Ref}) \cdot TK_1 + (\vartheta_\rho - \vartheta_{Ref})^2 \cdot TK_2$$

with:

ρ_{Ref}	=	density value compensated relative to reference temperature
TC_1	=	linear temperature coefficient TC_1
TC_2	=	square temperature coefficient TC_2
ρ_M	=	measured density value
ϑ_r	=	product temperature
ϑ_{Ref}	=	reference temperature

With minor temperature changes (approx. ± 20°C) it suffices, in most cases, to enter the linear coefficient (TC_1).

Calculation of the linear temperature coefficient

Example:

Product:	HCl water mixture
Meas. range:	20 ... 40 wt % HCl
Temperature range:	10 ... 30 °C
Unit of measure:	g/cm³

The temperature coefficient at average concentration (30 %) is calculated as follows:

$$TK = -\frac{\rho_1 - \rho_2}{\vartheta_1 - \vartheta_2} = -\frac{1.1551 - 1.1433}{10 - 30} = 0.00059$$

with

ρ_1	=	Density in g/cm³ bei ϑ_1
ρ_2	=	Density in g/cm³ bei ϑ_2

The input value is therefore *5.9 e-04*.

For other units of measure (e.g. °Bx, %-concentration, g/l, etc.), the temperature coefficients have to be converted accordingly. To do this, one first has to calculate the density change/unit of measure obtained for the measuring range (e.g. %):

$$\frac{\text{Density change}}{\text{Concentration change}} = \frac{\Delta\rho}{\Delta C} = \frac{\rho_{C1} - \rho_{C2}}{C_1 - C_2}$$

with

ρ_{C1} = Density at average temperature and minimum concentration in measuring range

ρ_{C2} = Density at average temperature and maximum concentration in measuring range

Example::

ρ_{C1} at 20 °C and 20 % HCl = 1.0979 g/cm^3

ρ_{C2} at 20 °C and 30 % HCl = 1.1493 g/cm^3

$$\frac{\Delta\rho}{\Delta C} = \frac{1.0979 - 1.1493}{20\% - 30\%} = 0.00514 \frac{g}{cm^3 \cdot \%}$$

The temperature coefficient TC' for the unit % is calculated as follows:

$$TC' = \frac{TC_1}{\frac{\Delta\rho}{\Delta C}} = \frac{0.00059}{0.00514} = 0.11478$$

The input value is therefore *1.1478 e-01*.

Calculating the square temperature coefficient

If significant temperature variations are likely to occur in the product (approx. > ± 20°C), it is advisable to enter the square temperature coefficient as well.

Procedure:

1. Calculate TC_1 (see above).
2. With TC_1 calculate nominal value ρ_2' at higher temperature:

$$\rho_2' = \rho_1 + (\vartheta_1 - \vartheta_2) \cdot TC_1$$

3. Take actual density value ρ_2 from table.
4. Calculate TC_2:

$$TC_2 = \frac{\rho_2' - \rho_2}{(\vartheta_1 - \vartheta_2)^2}$$

Enter calculated value as temperature coefficient TC_2.

Example:

Ethanol, concentration 30 %, reading in g/cm^3, relative to 10 °C.

1. Temperature coefficient in range 10 ... 20 °C:

$$TC_1 = -\frac{0.9599 - 0.9540}{10 - 20} = 0.00059$$

   Input value TC_1: 5.9 e -04

2. Calculate nominal value ρ_2' of density using the calculated TC_1 at 100 °C:

$$\rho_2' = 0.9599 + (10 - 100) \cdot 0.59 \cdot 10^{-3}$$

3. Table value of ρ_2: 0,8936
4. This yields TK_2:

$$TC_2 = \frac{0.9068 - 0.8963}{(10 - 100)^2} = 1.2962 \cdot 10^{-6}$$

The input value for TC_2 is therefore *1.2962 e-06*.

Calculation of the temperature coefficient without table values ??

Linear temperature coefficient (only TC_1):

If you don't know the temperature coefficient of the product to be measured, you can calculate it using the method described below. Prerequisite is that the measurement device is calibrated at reference temperature using at least two value pairs.

Procedure:

1. Fill measuring path with the product to be measured. The density should be about the average value of the requested measuring range.
2. Disable temperature compensation (instrument configuration without TC).
3. Start measurement and wait for a short time until the reading shows the value of the product in the measuring path.
4. Read off and write down the density or concentration value ρ_1.
5. Read off product temperature ϑ_1 write it down and enter it in reference temperature.
6. Change temperature of product in the measuring path through heating or cooling by approx. 10 to 15 °C.
7. Write down the displayed density or concentration value ρ_2 and the displayed temperature ϑ_2.
8. Calculate the temperature coefficient as follows:

$$TK = -\frac{\rho_1 - \rho_2}{\vartheta_1 - \vartheta_2}$$

9. Enter the calculated temperature coefficient in TC_1. TC_2 must contain "0".
10. Enable temperature compensation in the device configuration. The same density or concentration value as noted under 4. must now be available again.

Square Temperature Coefficient (TC_1 and TC_2):

To calculate the square coefficient one first has to calculate the linear coefficient, starting from the reference temperature (here: lowest temperature), as described above. The initial temperature should equal the lowest product temperature.

After calculation of the linear coefficient with temperature compensation enabled, increase the product temperature by at least 40 to 50 °C. From the resulting change in reading and the associated temperature change one then calculates the square coefficient TC_2:

$$TK_2 = \frac{\rho_{soll} - \rho_A}{(\vartheta_1 - \vartheta_2)^2}$$

with

ρ_{target} = actual density value (table value or lab value at this temperature)

ρ_A = displayed density value

ϑ_1 = original temperature

ϑ_2 = temperature at ρ_A

Enter the calculated value at TC_2. Now the originally noted density or concentration value must be obtained again.

7.6 Software Versions

Two programs are needed to operate the SENSseries:

- *Embedded Software:* It is stored in the SENSseries SENSseries (Hardware).
- *Device Description (DD):* It is stored on the HART® Communicator.

To ensure that operation works smoothly, the DD version has to correspond to the embedded software on the SENSseries.

Proceed as follows to find the revision of the Device Description (DD) LB 480. The Device Description is the user interface the HART® Communicator requires to operate the respective device, e.g. the SENSseries LB 480. Each device requires its own DD.

7.6.1 Software Management

Show software versions

If the Start menu is not displayed, push HOME ***HOME*** to go to the Start menu.

▶ Exit the Start menu by selecting the button "to the left".

▶ Select **UTILITY**.

▶ Select **SIMULATION**.

▶ Select **BERTHOLD TECHNOLOGIES**.

▶ Select LB 480.

Here you can read the revision of the Device Revision (Dev vX) and the Device Description (DD vX).

Type of modifications

HART® distinguishes two different types of software modifications:

- Modifications affecting functions and thus the DD and the embedded software.

  This type of modification will affect the compatibility to previous software versions.
- Modifications which only affect the DD or only the embedded software.

  These modifications do not affect the compatibility to the previous software version.

Example:

If a new function is added which allows you to enable or disable the digital input of the SENSseries, then the embedded software has to be changed.

Likewise, a selection option has to be provided in the DD. Since this function was not yet implemented in previous versions, this will lead to incompatibilities with older software versions.

Two version numbers each

HART® has therefore introduced a system for identification which, at the same time, also describes the compatibility of the DD with the embedded software. Therefore, there are two HART®-specific version numbers for each software modification.

- A number that is incremented for *each* modification:
  - Software rev for the embedded software
  - DD v for the Device Description
- A number that is incremented only *if compatibility with the previous software is no longer given:*
  - Fld dev rev for the embedded software
  - DD v for the Device Description

Below is a table of the software versions for the SENSseries LB 480 for the version with HART® Communicator:

Version in the embedded software in the SENSseries			Device Description	
	Software versions (displayed on the HART® Communicator			
	under ... ▸ **review**		under ... ▸ **simulation**	
Software version	Software rev	Fld dev rev	Dev v	DDv
1.00	1	1	1	1

Explanations

Software release in the SENSseries (embedded Software)

The software release of the embedded software in the SENSseries is described by the following three identifications:

- *Software version:* Berthold internal version number, e.g. 1.20
  - It is needed when the embedded software of the SENSseries is to be updated. The version appears in the file name, e.g. "LB480_V120.run".
- *Software rev:* ongoing revision number, e.g. 12
  - It is incremented with each embedded software modification.
  - Display of the *Software rev* see *page 3-302*.
- *Fld dev rev:* Field Device Revision, e.g. 3
  - This number will be incremented only when new commands have been implemented which create an incompatibility to previous DD versions.
  - It is stored in the embedded software of the SENSseries.
  - It shows which DD is required to utilize the full range of functions.
  - It is checked for compatibility by the DD (Dev v).
  - Display of the *Fld dev rev* see *page 3-302*.

Software release of the DD (Device Description)

The software release of the DD on the HART® Communicator is identified by two version numbers:

- *Dev v:* Device Version, e.g. 3

  Revision number of the DD on the Communicator.
  - It is incremented only for modifications where new commands have been implemented that create an incompatibility with previous versions.
  - It is checked for compatibility with the *Field Device Revision* (see above).
  - Display of the *Dev v* see *page 3-302*.
- *DD v:* DD Version, e.g. 3

  Consecutive number of the DD on the Communicator.
  - It is incremented for any DD modification.
  - If may be higher than the *Dev v*.
  - Display of the *DD v* see *page 3-302*.

Compatibility

You can load several different revisions onto the HART® Communicator. The Communicator compares the *Field Device Revision* of the SENSseries with the *Device Version* of the DD. The compatible DD version is started automatically.

Behind this chapter is a separate Chapter 7 Tables from LB491

What to do if ...

If no suitable DD is available on the HART® Communicator, then one of the following two things may happen:

Scenario 1:

The DD on the Communicator is older than the version of the embedded software in the SENSseries.

Example:
DD on the Communicator: **Dev v1**
Field Device Revision: **Fld dev rev: 2**

The following warning is displayed on the Communicator:

This means the DD has to be updated to utilize the full functionality of the detector.

Then follows the question: ***Continue with old description? Yes/No***

▶ Select ***Yes***.

You can continue working normally with the detectors. Only new functions that do not yet support the DD are not available.

Scenario 2:

The DD on the HART® Communicator is older than the version of the embedded software in the SENSseries:

Example:
DD on the Communicator: **Dev v2**
Field Device Revision: **Fld dev rev: 1**

Then the *Generic DD* starts. HART® does not allow that in this case an existing DD by the manufacturer will be loaded, as otherwise the program on the Communicator may crash. In the Generic DD you cannot calibrate and many parameters for the SENSseries are missing.

Universal Revision

All Berthold-DD's require the Universal Commands for HART® 6 or higher.

This requires that the HART® Communicator by Emerson Process, Model 375/475 is used.

Other HART®-compatible communicators with HART® 6 may also be used, provided they support Enhancements.

If the Communicator has a lower version than HART® 6, then the *Generic DD* will be started.

To determine the version of the Universal Commands, call the menu **Device Config ▸ Setup ▸ Identifications ▸ Device Revision ▸ Universal Rev.** on the HART® Communicator.

8

Error Handling

Errors are indicated by the error relay and/or via fault current. Error messages are displayed on the HART® Communicator. All error messages are stored in the error log together with date and time. To view the error log, select **Device Config ▶ Diagnostic ▶ Log ▶ Error Log**.

8.1 Error Handling Modes

The behavior in case of errors is dependent on the weighting set in Error Handling (**Device Config ▶ Setup ▶ Signal Condition ▶ Signal Parameter**, *chapter 2.16*, *page 3-202*): ***NORMAL*** or ***SENSITIVE***.

Both operation modes behave as follows:

- ***SENSITIVE***

  All faults cause the current output to report a *Fault current*. To also get warning messages, you must also evaluate the messages via the HART® signal or the digital output.

  The setting ***SENSITIVE*** is automatically enabled when the Safety Mode is selected.

- ***NORMAL***

  Only fatal errors are reported as a fault current. Thus, the measured value via the current signal will fail only if the measurement can no longer be used.

  To also get minor error and warning messages, you must also evaluate the messages via the HART® signal or the digital output.

IMPORTANT

*You may select the **NORMAL** setting only if hazards to persons or damage to property a as a result of a faulty measured value can be ruled out.*

Select ***SENSITIVE*** if system safety is an important issue. Use ***NORMAL*** if a failure of the measurement is non-critical for human health and the environment and production safety is an important issue.

To use the digital output for the above mentioned messages, you need to use the setting ***WARNING + ERROR*** on the menu **Digital Out Function** (**Device Config ▶ Setup ▶ I/O Setup ▶ Digital Output ▶ Digital Out Function**, see *chapter 2.26*, *page 3-221*).

8.2 Device Response to Errors

The following tables provide a description of the error codes, error and warning messages, information about the reason for the error and how to remedy the error. To keep the list clearer, we have created two separate lists for ***SENSITIVE*** and ***NORMAL***.

The list is so detailed as to cover and diagnose all possible error sources in such a radiometric measuring system. Thus, it is possible to offer the user a high level of safety and diagnostic options.

Meaning of the individual columns:

Identification	Meaning
x	An error message is issued.
–	*No* error message is output.
Error Log	The error that occurred is written to the error log.
HART®	An error telegram is digitally output via the HART® to the process control system. The control system must evaluate the HART® signal.
Digital Out	The digital output of the detector is actuated. In the standard version, this is an open collector; a relay output is also possible.
Fault current	The current output switches to fault current. As a rule, this is 22mA, i.e. the 4-20 mA measurement signal is no longer available. The measurement signal is then available only via the digital HART® protocol.
SHUTDOWN	The current output switches to fault current, the HV (high voltage on the photomultiplier) goes to 0V. The measurement stops and can only be restarted by a restart of the detector or a software reset after the problem is solved.
Self-repairing	If the error disappears, then the fault condition is removed automatically. If the error is not self-repairing, then you need to reset the error state by rebooting or software reset.
Quality of measurement value for Master and Slave (only HART®)[1]	
g	Measured value is good
u	Measured value is doubtful
f	Measured value is frozen
b	Measured value is bad

1. The digital HART® protocol conveys the measured value as well as its quality.

8.2.1 Error Signaling

Code	Error message	Error Handling N=Normal S=Sensitive	Error Log	HART®	Digital Out	Fault current	SHUTDOWN	Slave Status	Master Status	Self-repairing
101	HW module missing or not tested	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	b	b	–	x
102	Device data-set error	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
103	RAM Error	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
104	Device Error	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
105	Real time clock not valid	N	x	x	x			u	u	–
		S	x	x	x	x		b	b	–
106	Test mode active	N						g	u	–
		S						g	u	–
107	Watchdog reset	N	x					g	g	x
		S	x	x	x	x	x	b	b	–
108	Safety parameter invalid	N						g	g	–
		S	x	x	x	x		b	b	x
200	Data flow	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
201	Error by analog input calibration	N	x	x	x			u	u	–
		S	x	x	x	x		u	u	x
202	Clock signal deviation	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
300	Data flow	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
301	Error by ADC calibration	N	x	x	x			u	u	–
		S	x	x	x	x		u	u	–
302	Error by DAC calibration	N	x	x	x			u	u	–
		S	x	x	x	x		u	u	–
303	Supply 5.0V	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
304	Reference 2.0V	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
305	Reference 2.5V	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
306	ERROR GND CPU ST9	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
307	No impulses in measuring channel	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
308	No impulses in control channel	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
309	No impulses in auxiliary channel	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
310	Impulse difference measuring channel	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
311	Impulse difference control channel	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
312	Impulse difference auxiliary channel	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
313	Instable pulse rate	N						g	g	x
		S						g	g	x
314	Threshold of measurement channel 1	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
315	Threshold of measurement channel 2	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
316	Threshold of control channel 1	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
317	Threshold of control channel 2	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
318	Threshold of auxiliary channel 1	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
319	Threshold of auxiliary channel 2	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x
320	HV voltage	N	x	x	x			u	u	x
		S	x	x	x	x	x	b	b	–
321	Generated HV voltage	N	x	x	x	x		b	b	x
		S	x	x	x	x	x	b	b	–
322	HV reached its limit value	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
323	HV average is 20% lower than default HV	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
324	HV average is 40% higher than default HV	N	x	x	x			g	g	x
		S	x	x	x	x		u	u	x
325	Lower PMT current limit is exceeded	N	x					u	u	x
		S	x					u	u	x
326	Upper PMT current limit is exceeded	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
327	Temperature sensor deviation	N	x	x	x			u	u	x
		S	x	x	x	x		b	b	x

Code	Error message	Error Handling N=Normal S=Sensitive	Error Log	HART®	Digital Out	Fault current	SHUTDOWN	Slave Status	Master Status	Self-repairing
328	Temperature warning	N	x	x	x			g	g	x
		S	x	x	x	x		b	b	x
329	Temperature out of allowed limits	N	x	x	x	x		b	b	x
		S	x	x	x	x	x	b	b	–
330	Detector malfunction	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
400	Data flow	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
401	Supply 11V	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
402	Supply 5V	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
403	Supply 5VM	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
404	Supply 3.3V	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
405	RS-485 Communication error	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
406	Remote device warning	N	x	x	x			u	u	x
		S	x	x	x			u	u	x
407	Remote device error	N	x	x	x	x		b	b	x
		S	x	x	x	x		b	b	x
500	Data flow	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
502	Digital input malfunction	N	x	x	x			g	u	x
		S	x	x	x	x		g	b	x
503	Digital output malfunction	N	x	x	x	x		g	g	x
		S	x	x	x	x		g	g	x
504	Pt100 Temperature	N	x	x	x	x		g	u	x
		S	x	x	x	x		g	u	x
600	Data flow	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
601	License Key Error	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
602	Impulse rate limit exceeded	N	x	x	x			g	u	x
		S	x	x	x	x		g	b	x

Code	Error message	Error Handling N=Normal S=Sensitive	Error Log	HART®	Digital Out	Fault current	SHUTDOWN	Slave Status	Master Status	Self-repairing
603	Measuring Error check <Error Status>	N	x	x	x			g	u	–
		S	x	x	x	x		g	b	–
604	Decay Compensation Error	N	x	x	x			g	u	–
		S	x	x	x	x		g	b	–
605	Source Exchange	N	x	x	x			g	g	x
		S	x	x	x			g	u	x
606	Radiation Interference	N	x	x	x			g	f	x
		S	x	x	x	x		g	f	x
607	RID Interference	N	x	x	x			g	g	x
		S	x	x	x			g	g	x
608	Inherited Message	N	x					g	g	x
		S	x					g	g	x
609	Inherited Message	N	x					g	g	x
		S	x					g	g	x
610	Pulse Rate Limit Min	N	x	x	x			g	u	x
		S	x	x	x	x		g	b	x
611	Pulse Rate Limit Max	N	x	x	x			g	u	x
		S	x	x	x	x		g	b	x
612	Pt100 missing	N	x	x	x			g	b	x
		S	x	x	x	x		g	b	x
613	Pt100 faulty	N	x	x	x			g	b	x
		S	x	x	x	x		g	b	x
700	Data flow	N	x	x	x	x	x	b	b	x
		S	x	x	x	x	x	b	b	–
701	Impulse difference	N	x	x	x	x		g	g	x
		S	x	x	x	x		g	g	x
702	Current loop malfunction	N	x	x	x	x		g	g	x
		S	x	x	x	x		g	g	x
703	CLoop Monitoring Disabled	N	x					g	g	–
		S	x					g	g	–
704	ERROR GND CPU ST6	N	x	x	x			g	g	x
		S	x	x	x	x		g	g	x
900	Data Flow	N	x	x	x	x	x	b	b	–
		S	x	x	x	x	x	b	b	–
901	Signal Unlocked	N	x	x	x			g	u	x
		S	x	x	x	x		g	b	x

8.2.2 Error Handling

Code	Error message	Error reason	Error Handling
101	HW module missing or not tested	Hardware error	The error can be eliminated only by replacing the detector or the detector electronics.
102	Device data-set error		
103	RAM Error		
104	Device Error		
108	Safety parameter invalid		
200	Data flow		
201	Error by analog input calibration		
202	Clock signal deviation		
300	Data flow		
301	Error by ADC calibration		
302	Error by DAC calibration		
303	Supply 5.0V		
304	Reference 2.0V		
305	Reference 2.5V		
306	ERROR GND CPU ST9		
307	No impulses in measuring channel		
308	No impulses in control channel		
309	No impulses in auxiliary channel		
310	Impulse difference measuring channel		
311	Impulse difference control channel		
312	Impulse difference auxiliary channel		
313	Instable pulse rate		
314	Threshold of measurement channel 1		
315	Threshold of measurement channel 2		
316	Threshold of control channel 1		
317	Threshold of control channel 2		
318	Threshold of auxiliary channel 1		
319	Threshold of auxiliary channel 2		
330	Detector malfunction		
400	Data flow		
401	Supply 11V		
402	Supply 5V		
403	Supply 5VM		
404	Supply 3.3V		
500	Data flow		
502	Digital input malfunction		
503	Digital output malfunction		
504	Pt100 Temperature		
600	Data flow		
700	Data flow		
701	Impulse difference		
702	Current loop malfunction		
704	ERROR GND CPU ST6		
900	Data Flow		

Code	Error message	Error reason	Error Handling
105	Real time clock not valid	Date invalid	If the device was turned off, check or update the date and time. If the unit was in operation when the error occurred, then there is a defect in the hardware. The error can be eliminated only by replacing the detector electronics.
106	Test mode active	A safety parameter could not be set.	Check or reset all test settings in the Service menu.
107	Watchdog reset	A line failure has triggered an error in the program flow and the device has been restarted automatically.	If the error occurs again, the detector electronics has to be replaced. If the exchange is unsuccessful, search for electromagnetic interference.
108	Safety Parameter invalid	Safety parameter invalid	Check in the Diagnostics menu which of the safety parameters could not be set and why.
320	HV voltage	A faulty measurement was detected in the high voltage.	The error can be eliminated only by replacing the detector electronics or the photomultiplier.
321	Generated HV voltage		
322	HV reached its limit value		
323	HV average is 20% lower than default HV		
324	HV average is 40% higher than default HV		
325	Lower PMT current limit is exceeded	The PMT current is >50µA.	Either there is strong radiation interference, or the photomultiplier (PMT) is defective and therefore has to be to exchanged.
326	Upper PMT current limit is exceeded	The PMT current is >100µA.	
327	Temperature sensor deviation	The redundantly measured electronics temperatures differ more than 10 °C from each other.	The error can be eliminated only by replacing the detector electronics.
328	Temperature warning	The detector temperature has exceeded 55°C (UniSENS, SuperSENS, TowerSENS) or 60°C (CrystalSENS)	Assemble water cooling.
329	Temperature out of allowed limits	The detector temperature has exceeded 65°C (UniSENS, SuperSENS, TowerSENS) or 70°C (CrystalSENS)	We recommend to return the detector for repair to the manufacturer, even if the detector appears to be functioning still.
405	RS-485 Communication error	Master-slave communication disturbed.	Check the wiring between master and slave, the detector address and the supply voltage.
406	Remote device warning	A slave returns a warning message.	Go to the Diagnostics menu and check in the local slave table which warning message is indicated for which slave.
407	Remote device error	A slave returns an error message.	Go to the Diagnostics menu and check in the local slave table which error message is indicated for which slave.
504	Inherited Message	A new software application has been installed and a previously stored fault is not existent in the new application.	Clear the fault memory with **Reset Error Log**.

Code	Error message	Error reason	Error Handling
601	License Key Error	The license key is invalid or does not match the application.	Check and correct license key. If necessary, consult BERTHOLD TECHNOLOGIES.
602	Impulse rate limit exceeded	The count rate has exceeded 1 million pulses.	Either there is strong radiation interference or there is a defect in the detector electronics and the photomultiplier.
603	Measuring Error check <Error Status>	During decay compensation, an error was detected in the measurement parameters.	For more information on the cause of the error please go to the Diagnostics menu under **Error Status**.
604	Decay Compensation Error	The decay compensation could not be performed.	The error can be eliminated only by replacing the detector electronics.
605	Source Exchange	Based on the criteria entered, it was found that the source is too weak.	Replace source at the next opportunity. Please contact the manufacturer.
606	Radiation Interference	Based on the criteria entered radiation interference was detected.	Check whether welding seam tests were performed, or whether the criteria are set incorrectly or not optimally.
607	RID Interference	Message in this software is not active.	
608 609	Inherited Message	A new software application has been installed and a previously stored fault is not existent in the new application.	Clear the fault memory with **Reset Error Log**.
610	Pulse Rate Limit Min	The count rate entered in the parameter the Cps Lower Limit has been exceeded.	The message is dependent on the setting on the device. Unless the message is not displayed or incorrectly, you have to check the corresponding threshold setting in the menu.
611	Pulse Rate Limit Max	The count rate entered in the parameter the Cps Upper Limit has been exceeded.	
612	Pt100 missing	The Pt100 input is open, or the measured Pt100 temperature has exceeded 180°C.	Check wiring and Pt100, if necessary.
613	Pt100 faulty	The Pt100 input is open, or the measured Pt100 temperature has exceeded -30°C.	Check wiring and Pt100, if necessary.
703	CLoop Monitoring Disabled	The monitoring of the current output is turned off. Message always appears when restarting.	Enable the monitoring on the I/O Setup menu, unless there are reasons to keep the monitoring switched off.
901	Signal Unlocked	The detector has been unlocked with the password.	The warning message was generated as a result of the setting in **Signal Unlocked**, see *chapter 2.16*, *page 3-202*.

8.3 Trouble Shooting

Problem	Cause	Solution
No signal	System does not work	Check power supply
Count rate too low	Shielding not open or not open correctly.	Check lock and secure it in position OPEN
	Alignment of the effective radiation towards the detector is incorrect	Correct and optimize alignment
	Container installations in the beam path	Offset irradiation plane
	Wall deposits in the container	Remove wall deposits or perform new calibration if wall deposits cannot be removed.
	Source has reached the end of its service life	Replace source
No or incorrect density reading	Entry of final density values incorrect	Check calibration values and density reading
Density reading fluctuates strongly	Time constant too small	Increase time constant in the Parameter menu (min. 20s)
	Wrong calibration	Check calibration values
	Rapid switchover with too small Sigma value	Increase Sigma value or disable automatic time switch
	Count rate too low (see above)	Check age of source and irradiation level; replace detector
Density reading drifts	Detector stabilization faulty	Replace detector
	Multiplier faulty	Exchange multiplier
Current output at 2mA	Resistance in the current loops is or was too high. Errors can also be caused by a loose connection in the current loop.	Bring resistance to a value below 500 ohms. Then restart detector by **Software Reset** or by turning the power supply off/on.
Current output at 24mA	Current output faulty or defective.	Recalibrate current output. Then restart detector by **Software Reset** or by turning the power supply off/on. If the current output cannot be calibrated, the detector needs to be repaired.

8.4 Reset

The SENSseries detectors can be reset in various ways. Use the menu **Device Config ▶ Setup ▶ Service** to perform a software reset or reset all settings to factory default.

1. Software reset: ***SW RESET***

   Starts the new detector, the parameters remain unchanged. The function corresponds to the switching off and on of the supply voltage.

2. Factory reset: ***FACTORY RESET***

   Resets most settings to factory default. Some settings, such as the adjustment of current output and the license key will be preserved. Turn the HART® Communicator off and on again after you have initiated the reset.

Switching the supply voltage off/on also causes a reset similar to the software reset, but in this case possible "hardware blocks" will also be fixed. The parameters remain unchanged.

See also *chapter 6.2, "Master Reset"*, *page 3-285*.

8.5 Operation Modes during Measurement

Select **Operating Mode** (menu **Live Display**, *page 3-190*), to view the current operating status:

– The measurement is in the normal measurement mode or in the halt mode.

– A warning or an error is indicated.

– A test value is enabled.

See also *chapter 2.54*, **Operating Mode**, *page 3-245*, and the error lists in the previous chapter.

8.6 Error Reset

If an error or a warning is identified, an error message is displayed. This error message must be reset. If the error still occurs after resetting, it will be indicated again on the display.

If the error is corrected, but the error message is still displayed, the error can be acknowledged as follows:

- with **Acknowledge Error** under **Diagnostic ▶ Operating Status**
- with **Software Reset** under **Device Config ▶ Setup ▶ Service ▶ Reset Device**
- by switching the supply voltage off and on at the detector

8.7 Fault Current

There are four different ways of how the current output should respond to errors:

- *High:* Hold at 22 mA.
- *Low:* Hold at 2 mA.
- *Hold:* Hold last measured value.
- *Value:* Hold at a selected value between 2 and 22 mA. The corresponding value must be defined in **Error Current Value** (see *page 3-219*).

Example for *High*

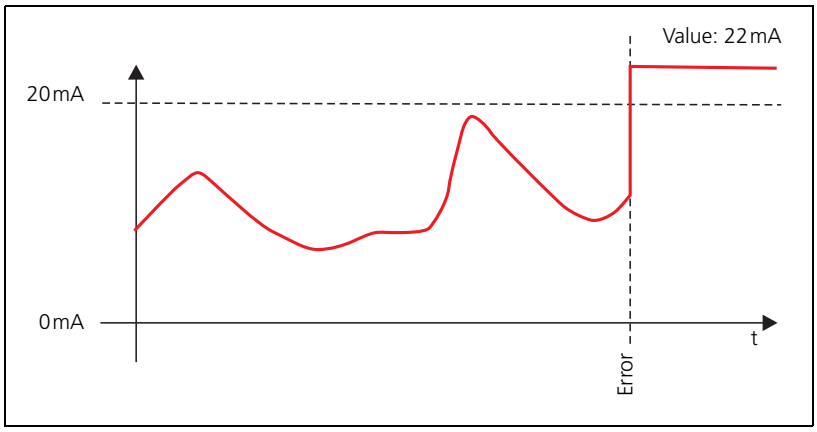


Fig. 8-1 Example for High

Example for *Hold*

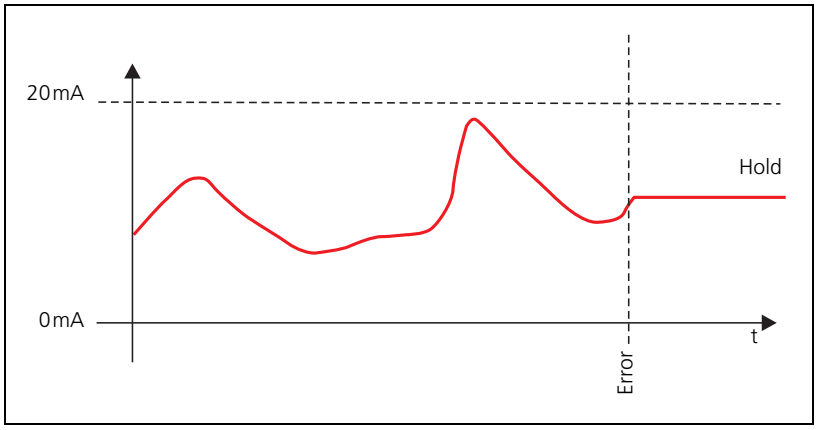


Fig. 8-2 Example for Hold

9 Tables

9.1 Absorption coefficients

The absorption coefficients were calculated for average concentrations. Depending on the resolution behavior, these values may differ with other concentrations.

Product	Unit of measurement		
	g/cm^3	% concentration	Conc. in g/l
Whole milk	-0.0737	-0.00018	-0.000017
Skim milk	-0.0737	-0.000027	-0.000295
Whey	-0.0737	-0.000294	-0.0000254
Sugar solution	-0.0657	-0.00044	-0.000021
Hydrochloric acid (HCl) - H_2O	-0.0608	-0.0003	-0.000025
Sulfuric acid (H_2SO_4) - H_2O	-0.0623	-0.0005	-0.000036
Nitric acid (HNO_3) - H_2O	-0.0576	-0.00036	-0.000027
Sodium hydroxide (NaOH) - H_2O	-0.0664	-0.00069	-0.000049
Ethanol (C_2H_6O) - H_2O	-0.0677	0.00014	0.000018
Propyl alcohol (C_3H_8O) - H_2O	-0.0673	0.00015	0.0000186
Glycerin ($C_3H_5(OH_3)$) - H_2O	-0.0667	-0.00017	-0.000015

9.2 Temperature coefficients

Water temperature coefficients can be used for many low concentration products, such as milk, beer, whey, starch suspension, etc. For upgraded milk, whey, cottage cheese, etc. the values given for sugar solution can be used with good approximation.

Temperature coefficients for water

Temperature in °C	Input value at g/cm^3
10	1.5000E-04
20	2.0300E-04
30	2.9900E-04
40	3.8000E-04
50	4.5700E-04
60	5.1300E-04
70	5.7100E-04
80	6.2350E-04
90	6.7000E-04

Temperature coefficients for sugar solution

Concentration in weight %	Aver. temp. in °C	Input value at			
		g/cm^3	g/l	%	°Be
10	20	0.0002377	0.621	0.05748	0.000823
30	20	0.000341	0.908	0.07144	0.001245
50	20	0.000436	1.196	0.0794	0.001488
70	20	0.000518	1.457	0.0855	0.00355
10	50	0.000472	1.247	0.1167	0.00339
30	50	0.000582	1.395	0.1111	0.00302
50	50	0.000559	1.536	0.1033	0.00254
70	50	0.000588	1.654	0.0983	0.00475
10	70	0.000582	1.538	0.145	0.00531
30	70	0.000608	1.631	0.131	0.00426
50	70	0.000627	1.718	0.117	0.00328
70	70	0.000632	1.768	0.106	0.00561
10	80	0.000632	1.665	0.1583	0.00636

Concentration in weight %	Aver. temp. in °C	Input value at			
		g/cm³	g/l	%	°Be
30	80	0.000649	1.173	0.1401	0.00491
50	80	0.000658	1.794	0.1223	0.00365
70	80	0.000641	1.785	0.1072	0.00582

Temperature coefficients for H_2O - H_2SO_4

Concentration in weight %	Aver. temp. in °C	Input value at			
		g/cm³	g/l	%	°Be
20	30	5.9500E-04	1.0220E+00	8.0000E-02	5.3100E-03
50	30	6.9500E-04	1.9320E+00	1.0300E-01	7.7300E-03
80	30	1.0150E-03	2.5190E+00	1.0000E-01	4.9900E-03
20	60	6.3500E-04	1.1070E+00	8.8000E-02	1.2920E-02

Temperature coefficients for H_2O - HCl

Concentration in weight %	Aver. temp. in °C	Input value at			
		g/cm³	g/l	%	°Be
10	25	3.3000E-04	7.3600E-01	6.7200E-02	2.9300E-03
30	25	6.0000E-04	1.5720E+00	1.2150E-01	8.0000E-03
10	75	5.3800E-04	1.1960E+00	1.1160E-01	4.1450E-02
30	75	5.7600E-04	1.6610E+00	1.3330E-01	4.4380E-02

Temperature coefficients for H_2O - NaOH

Concentration in weight %	Aver. temp. in °C	Input value at			
		g/cm³	g/l	%	°Be
10	30	0.00047	0.528	0.04315	0.00436
30	30	0.00062	0.974	0.05964	0.00308
50	30	0.00072	1.44	0.0759	0.00684
10	60	0.00055	0.628	0.0521	0.0064
30	60	0.00065	1.02	0.0634	0.00353
50	60	0.0007	1.404	0.075	0.00681

9.3 Density of Water as a Function of the Temperature

Temp. in °C	Density in g/cm^3	Temp. in °C	Density in g/cm^3	Temp. in °C	Density in g/cm^3
10	0.99973	40	0.99224	70	0.97781
11	0.99963	41	0.99185	71	0.97723
12	0.99951	42	0.99146	72	0.97665
13	0.99939	43	0.99106	73	0.97607
14	0.99926	44	0.99065	74	0.97548
15	0.99911	45	0.99024	75	0.97488
16	0.99896	46	0.98982	76	0.97428
17	0.99879	47	0.98939	77	0.97368
18	0.99861	48	0.98896	78	0.97307
19	0.99843	49	0.98852	79	0.97425
20	0.99823	50	0.98807	80	0.97183
21	0.99801	51	0.98761	81	0.97120
22	0.99779	52	0.98715	82	0.97057
23	0.99755	53	0.98668	83	0.96993
24	0.99731	54	0.98621	84	0.96929
25	0.99706	55	0.98673	85	0.96864
26	0.99680	56	.98524	86	0.96799
27	0.99653	57	0.98475	87	0.96734
28	0.99625	58	0.98425	88	0.96668
29	0.99597	59	0.98375	89	0.96601
30	0.99567	60	0.98324	90	0.96534
31	0.99536	61	0.98272	91	0.96467
32	0.99504	62	0.98220	92	0.96399
33	0.99472	63	0.98167	93	0.96330
34	0.99439	64	0.98113	94	0.96261
35	0.99405	65	0.98059	95	0.96192
36	0.99370	66	0.98005	96	0.96122
37	0.99335	67	0.97950	97	0.96052
38	0.99299	68	0.97894	98	0.95981
39	0.99262	69	0.97838	99	0.95910

10

Setup Protocol

For reasons of clarity, only those parameters are listed in the following list which have a decisive influence on the measured signal.

As an alternative to completing the list below, you can also transfer and print the data digitally, via the HART® signal. See also *chapter 1.5, "Archiving Parameter Sets", page 3-179*.

▶ After commissioning, enter the parameters in the following parameter list in order to document the start-up.

TAG No.		**Date**	
Isotope		**Activity**	
Source no.		**Detector**	
Product		**HV**	

Path	Parameters	Unit	Standard	SETUP
Device Config ▶ Meas Parameter ▶ Meas Data				
	Background	cps	50	
Device Config ▶ Meas Parameter ▶ Meas Data ▶ Meas Table				
Point	**Level**	**Rate**	**Rate at Op**	**Comp Rate**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				

Path	Parameters	Unit	Standard	SETUP
Meas Parameter ▶ Meas Settings				
	Time Const	s	20	
	Nuclide	Cs-137 / Co-60	Cs-137	
	Cal Method	1-POINT LIN MULTIPOINT 1-POINT EXP 2-POINT EXP	MULTIPOINT	
	Cal Curve Type	STANDARD / REVERSED	STANDARD	
	Threshold	%	60%	
	Hysteresis	%	5%	
	Compensation Mode	OFF AUTO PRC MANUAL GDA AUTO GPC	OFF	
Device Config ▶ Setup ▶ Sensor Configuration ▶ Date - Time				
	Date	MM/DD/YYYY		
	Time	hh:mm:ss		
Device Config ▶ Setup ▶ Sensor Configuration ▶ Sensor Settings				
	Detector Code	0 ... 50	0	
	HV Mode	AUTO / MANUAL		
	HV Live	V		
	HV Average	V		
	HV Manual	V		
	HV Default	V		
Device Config ▶ Setup ▶ Signal Condition ▶ Signal Parameter				
	Time Const	s	20	
	Error Handling	NORMAL / SENSITIVE	NORMAL	
	Signal Unlocked	OFF / ON	OFF	
Device Config ▶ Setup ▶ Signal Condition ▶ Reading Range				
	Lower Range Value	%	0	
	Upper Range Value	%	100	

Path	Parameters	Unit	Standard	SETUP
Device Config ▶ Setup ▶ Signal Condition ▶ Signal Dependency				
	Response Mode	DISABLED RAPID SWITCH RAD INTERFERENCE	DISABLED	
	Io Factor		1.5	
	Waiting Time	s	60	
	RI Sigma		10	
	Meas Delay Time	s	4	
Device Config ▶ Setup ▶ I/O Setup ▶ Current Output				
	Current Loop Montitoring	DISABLED ENABLED	ENABLED	
	Loop Alarm Type	HIGH LOW HOLD LAST VALUE VALUE	HIGH	
	Error Current Value	mA	22.00	
	Current Lower Limit	mA	3.80	
	Current Upper Limit	mA	20.50	

Notes:

Subject to change in the course of further technical development.

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Notes:

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